EGG-M-90207
Conf-9005178--4

TECHNOLOGIES FOR SORTING, ASSAYING, CLASSIFYING, AND CERTIFYING TRANSURANIC WASTE WITHIN THE UNITED STATES

EGG-M--90207

DE91 006069

Donald G. Pound[a]
Idaho National Engineering Laboratory
EG&G Idaho, Inc.

ABSTRACT

At the Idaho National Engineering Laboratory (INEL), the Stored Waste Examination Pilot Plant (SWEPP) was developed to provide nondestructive examination and assay techniques for examining and certifying TRU wastes without opening the waste container. This technology was developed, primarily for stored TRU waste, to evaluate waste package compliance with Waste Disposal Acceptance Criteria and Transportation requirements prior to shipment. These techniques include real-time x-ray radiography, passive and active neutron assay, and ultrasonic container integrity examination. These techniques provide the necessary information to ensure safe transportation, handling, and disposal of the waste at the Waste Isolation Pilot Plant (WIPP).

INTRODUCTION

A major objective of the U.S. Department of Energy (DOE) Defense Waste Management Program is the proper management of defense-generated transuranic (TRU) waste. Transuranic waste is defined as material that has negligible economic value and is contaminated with alpha-emitting transuranium radionuclides with an atomic number greater than 92 with a half-life greater than 20 years and in concentrations greater than 100 nCi/g. The Defense Waste Management Plan[1] provides the strategy for achieving permanent disposal of newly-generated TRU and that currently in interim storage at several DOE sites.

---

a. Work supported by the U.S. Department of Energy Assistant Secretary for Defense Programs, Office of Defense Waste and Transportation Management under DOE Contract No. DE-AC07-76ID01570.

The Waste Isolation Pilot Plant (WIPP), a deep geological repository in the southwestern part of the United States near Carlsbad, New Mexico, will be a research and development facility for demonstrating the safe disposal of newly-generated and stored defense-generated TRU waste. Before the waste can be shipped to WIPP, it must be certified as meeting the Waste Acceptance Criteria (WAC) and the TRUPACT-II Authorized Methods for Payload Control (TRAMPAC), which ensure the safe disposal and transportation of the waste. These requirements include limits on the amount of respirable and dispersible fines in a waste package, free liquid restrictions, pyrophoric material restrictions, fissile inventory, waste form, layers of containment, and labeling requirements.

The Idaho National Engineering Laboratory (INEL) is a major storage site for defense-generated TRU wastes. At the end of 1987, 62,967 m^3 of contact-handled (less than 200 mrem/h) TRU waste were in storage awaiting retrieval and examination before shipment to WIPP. To support evaluation of waste container contents to ensure compliance with the WIPP-WAC, the Stored Waste Examination Pilot Plant (SWEPP) was developed to provide nondestructive examination and assay capabilities for examining and certifying the stored TRU waste without opening the waste containers. Nondestructive examination is a cost-effective method to ensure that worker radiological exposure is as low as reasonably achievable while ensuring that all waste acceptance criteria are met.

The primary nondestructive techniques used for certifying INEL stored TRU waste consist of real-time x-ray radiography (RTR), passive and active neutron assay, and container integrity examination of each waste container. These techniques are described in this paper. Other processes and techniques support waste certification but are not discussed in this paper. These include weighing, radiological surveys, waste container labeling, sampling program, and the data management system which supports waste container tracking, maintains data collected from the nondestructive examinations, and prepares the waste data package.

WASTE CERTIFICATION APPROACH

The approach to certifying stored TRU waste, some of which has been in storage since 1970, is based on a combination of information.

1. Waste Records: The Transuranic Waste Data Base is a computerized system that provides a base source of information for each waste container placed into interim storage.

   These data, which include a content code describing the physical contents of a waste container, are used to initially screen the waste for expected content prior to nondestructive examination and assay.

2. Waste Content Code Assessment: Each waste content code, which describes the physical contents of a waste container, was evaluated to determine waste form, packaging information, and compliance with the waste form requirements of the WIPP-WAC. This assessment identified the presence, or potential presence, of free liquids, sludges, pyrophoric materials, explosives, compressed gases, respirable or dispersible fines, toxins, and corrosive materials in the waste package. Based on this assessment, a determination was made as to whether the content code would meet the WIPP-WAC and TRAMPAC. This information is used by the technician operating the nondestructive examination equipment in evaluating waste container contents.

3. Nondestructive Examination Data: These data are obtained from real-time radiography (RTR), an assay system, and a container integrity system. These techniques, described in this paper, are the primary techniques used to nondestructively verify that the contents of a waste package meet WIPP-WAC and TRAMPAC requirements.

4. Sampling Program: A sampling program provides quality control of the waste certification process and verifies that WIPP-WAC and TRAMPAC requirements are met. Waste packages certified as meeting these requirements are selected using a statistical random sampling method, opened, and visually examined to ensure waste form compliance with the WIPP-WAC and TRAMPAC.

NONDESTRUCTIVE ASSAYING AND CLASSIFICATION TECHNIQUES

Real-Time Radiography (RTR)

The RTR system is a commercially available x-ray system that permits internal examination of waste packages and avoids the need for waste package opening and examination. The system combines x-ray radiography and fluoroscopy which allows the image of the object to be displayed in "real-time" while the examination takes place. The RTR examination is used to verify the physical contents of the waste container, the assigned content code, and determine if the waste meets WIPP-WAC and TRAMPAC requirements. Specifically, it identifies such materials as free liquids, respirable and dispersible fines, sealed containers > 1 gallon, and pressurized containers such as aerosol cans.

During development of RTR as a nondestructive examination technique at the INEL, a sampling program was conducted to determine the adequacy of RTR for certifying waste and to verify the Waste Content Code Assessment results for waste form compliance with the WIPP-WAC. Over 200 waste packages were sampled. Each waste package was first examined by RTR. Then the package was opened, and its contents visually inspected for compliance with the WIPP-WAC. The results of the visual examination were then compared to the results obtained during the RTR examination. Sampling program results demonstrated that RTR is an excellent technique for verifying the contents of a waste container. In addition, the sampling program verified the accuracy of the Waste Content Code Assessments and provided valuable information for developing specific requirements for the TRUPACT-II certification and the RTR operator qualification and training program.

The RTR system consists of a 420 kVp constant-potential x-ray head and an imaging system that includes monitors, a recorder, and video processor. The x-ray source and imaging system are housed in a lead-shielded, light-tight enclosure. The enclosure maintains radiation levels to less than 0.1 mrem/h. A cart and turntable assembly transports waste containers in and out of the enclosure. The turntable assembly permits rotation of three drums during the examination process. Removal of this turntable assembly allows one waste box (up to 1.2 x 1.2 x 2.1 m) to be examined. Figure 1 provides an overview of the system.

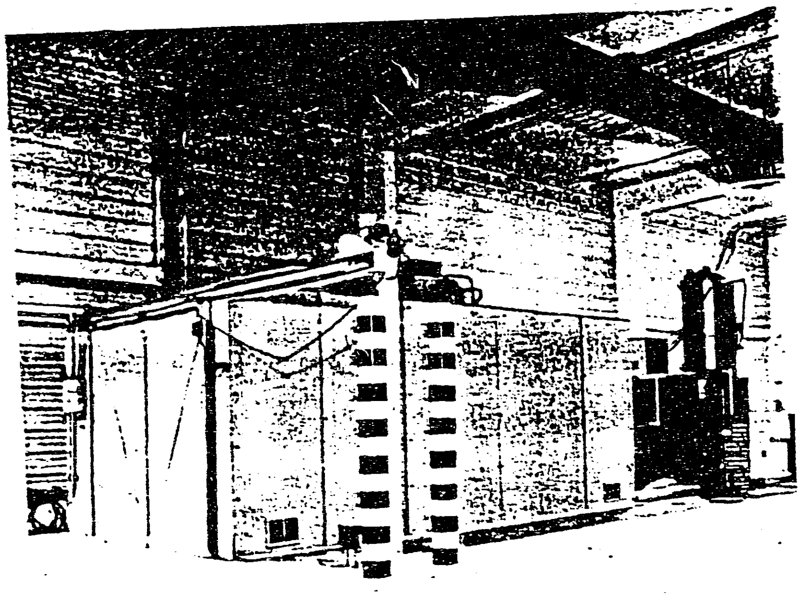
The 420 kVp constant-potential x-ray head is a standard, commercially available unit with an output dose rate of 11,000 R/min at 200 mm. The voltage of the unit can be varied from 90 to 420 kVp. The current can be varied from 0 to 10 mA at the maximum voltage.

The imaging system consists of a fluoroscopic screen and a low-light level Isocon (tradename) Closed-Circuit Television (CCTV) camera. The camera is mounted inside a shielded light-tight enclosure to protect the lens and electronic components from radiation damage. The camera has five lenses in a turret arrangement which permits remote selection of image sizes from 0.50 to 2X magnification. The lenses point at a first-surface mirror mounted at a 45^{o} angle, which in turn views the fluoroscopic screen. The fluoroscopic screen is 81.3 cm high by 61.0 cm wide and is covered with a gadolinium oxysulfide coating approximately 12 mils thick.

The output from the imaging system is supplied to two CCTV monitors at the operator's station. One monitor always presents the images directly from the camera. The operator can use the second monitor to view a processed image. The processing consists of videotaping and adding printed data on the videotape via a character generator.

Assay System

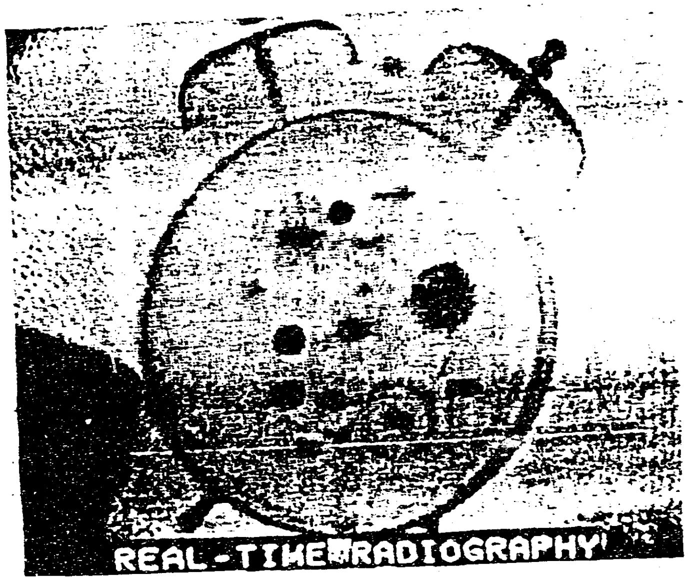
A Drum Assay System and a Box Assay System were developed by the Los Alamos National Laboratory for measuring the fissile material content and total TRU content of a waste package. Both systems use a differential die-away, active neutron interrogation technique (DDT) and passive neutron counting. In DDT, a pulse of fast (14-MeV) neutrons introduced into a polyethylene- and graphite-lined chamber is thermalized. These neutrons have a characteristic lifetime, called the system die-away time. If fissile materials are present in the chamber, some of the neutrons cause fissions. Prompt neutrons from these fissions are detected in specially designed ^{3}He neutron detectors that are sensitive only to fast neutrons.



RTR system exterior

RTR system interior

RTR system operator console

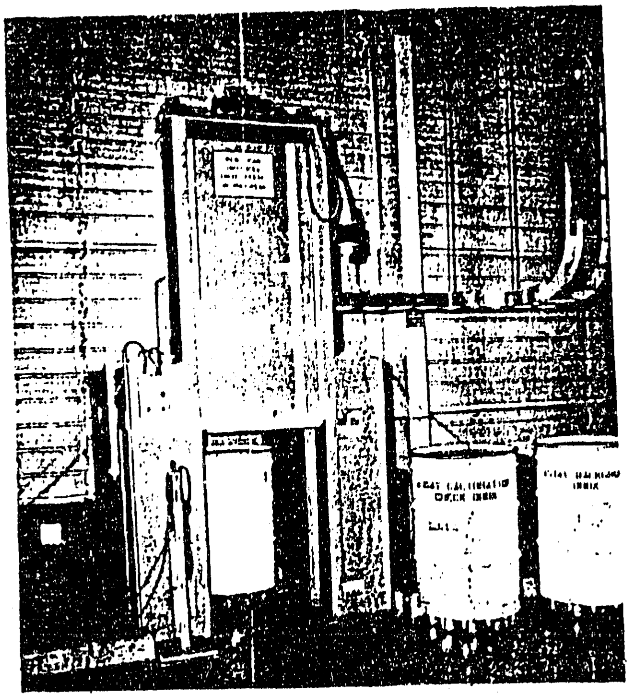


Radiograph of a clock

Figure 1. Real-Time X-Ray Radiography System

The Drum Assay System (Figure 2) is a rectangular assay chamber approximately 1.52 m wide by 3.25 m high and is designed to assay waste drums up to 314 L. The assay chamber walls are constructed of 25 cm-thick polyethylene, contained in steel jackets and lined with 10 cm-thick graphite. The polyethylene reduces neutron radiation levels and moderates the fast neutrons. The graphite serves as both a moderator to thermalize neutrons and as a neutron reflector. A neutron generator provides 1×10^6 neutrons/pulse with an energy of 14 MeV. The ^3He neutron detectors are located in the polyethylene surrounding the assay chamber. Detectors used for counting fast fission neutrons are shielded with a cadmium shield with a borated rubber lining to absorb thermalized neutrons. Two flux monitors are used to monitor neutron flux for normalizing detector response and for determining the effects of neutron absorption by the waste matrix. A computer system collects and analyzes data obtained during active and passive assays. Algorithms have been established for evaluating the data based on waste form and isotopic composition.

The fissile content of a waste drum is determined by active neutron interrogation (DDT) as well as passive neutron counting. The active assay provides the greatest accuracy for low fissile inventories; the passive assay is more accurate for the higher ones. Hence, data from the two are used accordingly. The thermal power density and total TRU content are derived by counting nonfission (single) neutrons produced by (α, n) reactions with elements such as O-18 or F-19 within the waste matrix and by Pu-240 spontaneous fission. The amount of single neutrons indicates total alpha activity. Since the average energy deposited per alpha decay is known, the thermal power can be calculated based on the total alpha activity. For non-alpha-emitting isotopes, such as Pu-241, the amount of these isotopes present is calculated using isotopic ratios. The total TRU content measurement is used to identify waste containers with less than 100 nCi/g TRU activity. These wastes will be disposed of as low-level waste.



Drum Assay System Exterior

Drum Assay Console

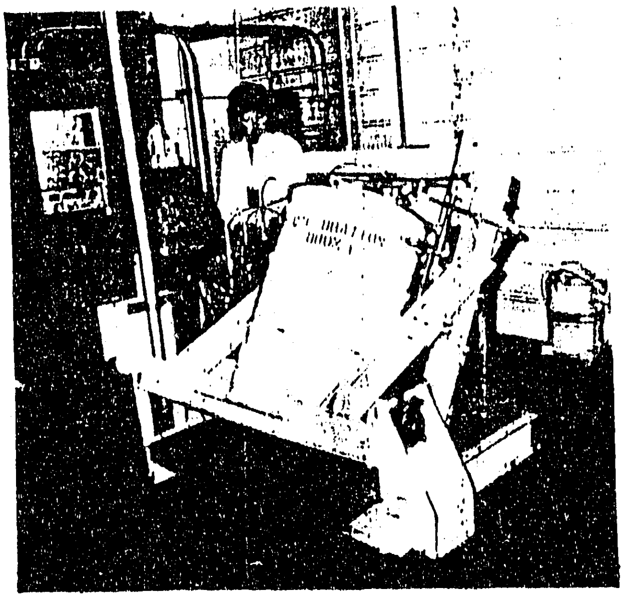
Figure 2. Drum Assay System

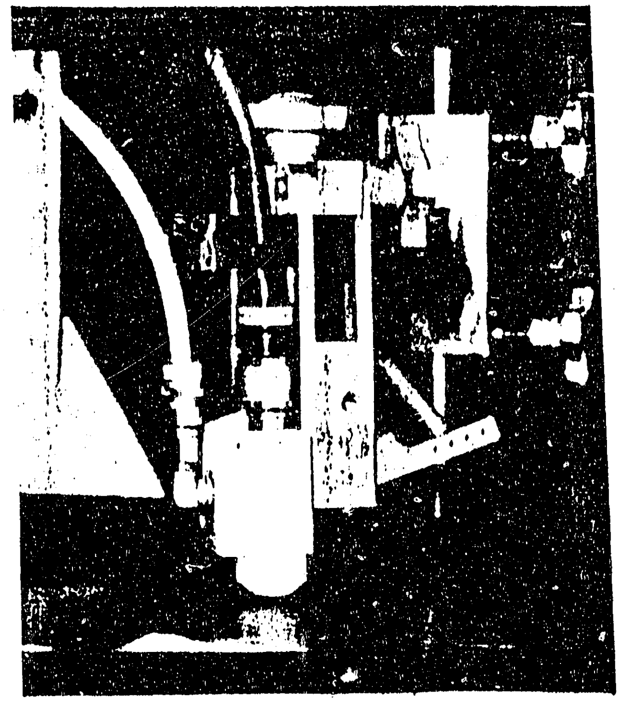
Container Integrity

The third NDE system is the container integrity system as shown in Figure 3. The purpose of this system is to ensure that a metal waste drum has not significantly deteriorated during interim storage and can be safely handled for transport and disposal at WIPP. The drum metal wall thickness is measured ultrasonically. The measurements and detected abnormalities are recorded with on-line data processing equipment.

A waste drum is placed in a tilt-rotation stand and tilted approximately 30^{o} from the upright position to maintain contact with the drive rollers and ultrasonic transducers. A recirculating water system provides water couplant to each sensor assembly. This system is capable of providing approximately 3.8 L per minute to each ultrasonic detector. A reservoir catch basin in the base of the stand collects the water. The water is filtered through a 125 μm and 10 μm filter before being returned to the detectors.

The container integrity system includes an eight-channel multiplexed ultrasonic digital thickness gauge, bubbler-type search unit holders, analog and digital recording, and digital data processing. Each search unit, which is mounted on the tilt stand to measure preselected drum locations, includes an ultrasonic transducer operating at 10 MHz to measure the container well thickness. The 10 MHz search units were found to be less sensitive to water path and angle changes than other search units evaluated. A measurement is obtained at 0.102 cm increments of drum travel for each of the eight search units. The recorded measurements are fed to a strip chart recorder and to a microcomputer. Approximately 15,000 measurements are taken. The microcomputer is programmed to calculate the average thickness, standard deviation, and the minimum thickness reading for each inch of drum travel for each search unit. A data summary of this information is used to determine if the waste drum still meets U.S. Department of Transportation (DOT) Type A specifications. The minimum allowable Type A wall thickness is 0.11 cm. Drums not meeting Type A specifications will be overpacked into an approved Type A container prior to shipment to WIPP.





Container Integrity System

Bubbler-Type Search Unit

Figure 3. Container Integrity System

Waste Classification

After completion of all nondestructive examinations, the data are reviewed by the Waste Certification Specialist. Wastes are classified and segregated into the following categories: (a) TRU waste certified as meeting WIPP-WAC and TRAMPAC requirements, (b) uncertifiable TRU waste that will require future processing to meet WIPP-WAC TRAMPAC requirements, and (c) low-level waste (containing less than 100 nCi/g TRU activity). Wastes certified as meeting WIPP-WAC and TRAMPAC requirements are stored for future shipment to WIPP. Waste shipments are scheduled to begin in October 1990.

SUMMARY

The above described nondestructive examination and assay techniques have also been established, or are in the process of being established, at several other DOE sites. These techniques are an integral part of the DOE strategy for ensuring proper management of newly-generated and stored defense-generated TRU waste.

REFERENCES

1. U.S. Department of Energy, the Defense Waste Management Plan, DOE/DP-0015, June 1983.

END

DATE FILMED

02 / 07 / 91