TRANSURANIC WASTE CHARACTERIZATION AND CERTIFICATION FOR SHIPMENT TO WIPP AT THE INEEL

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ABSTRACT

Department of Energy (DOE) weapons program legacy Transuranic (TRU) waste stored at the Idaho National Engineering and Environmental Laboratory (INEEL) is scheduled for shipment and disposal in the proposed Waste Isolation Pilot Plant (WIPP) facility in New Mexico beginning in 1998. The Radioactive Waste Management Complex (RWMC) located within the INEEL contains facilities and equipment to manage low-level, mixed (hazardous and radioactive), and TRU solid radioactive waste generated by the INEEL and other DOE laboratories and operations. The primary mission of the RWMC is safe disposal of INEEL-generated low-level waste (LLW), the temporary storage of mixed and TRU waste, and the characterization and certification of TRU waste in the Stored Waste Examination Pilot Plant (SWEPP) for shipment and disposal.

This paper provides an overview of the TRU waste characterization and certification activities at the INEEL. The normal process associated with the waste characterization involves a process flow through the SWEPP facility that begins with the drum selection and labeling effort and ends with the data review and quality verification activity. In between the drums pass through a number of inspection and assay stations including a real-time radioscopic system, a neutron assay system, and a gamma-ray spectrometer system. Each step in the process is designed to provide data required for reporting the waste physical, chemical, and radiological characteristics, and structural integrity of the drum in accordance with the transportation requirements and the acceptance criteria requirements for disposal at the WIPP. The TRU waste characterization and certification is critical path for the start of shipment of TRU waste out of the State of Idaho in accordance with the DOE and State of Idaho Settlement Agreement.

INTRODUCTION

Department of Energy (DOE) weapons program legacy Transuranic (TRU) waste stored at the Idaho National Engineering and Environmental Laboratory (INEEL) is currently being examined and characterized in preparation for shipment to a central disposal facility. The Radioactive Waste Management Complex (RWMC) located within the INEEL contains facilities and equipment to manage low-level, mixed (hazardous and radioactive), and TRU solid radioactive waste generated by the INEEL and other DOE laboratories and operations. The primary mission of the RWMC is safe disposal of INEEL-generated low-level waste (LLW), the temporary storage of mixed and TRU waste, and the characterization and certification of TRU. Much of this waste will be retrieved, nondestructively examined, assayed, certified and shipped to a centralized DOE disposal facility, such as the proposed Waste Isolation Pilot Plant (WIPP) facility in New Mexico.

The Transuranic Storage Area (TSA) within the RWMC is used for examination, segregation, characterization, and interim storage of TRU waste. Within the TSA, a facility referred to as the Stored Waste Examination Pilot Plant (SWEPP) provides space for the nondestructive assay and examination (NDA/E) systems that characterize and certify the various waste forms for shipping and disposal. The

characterization/certification process includes waste container warm-up, container venting, radiological survey, container weighing, container integrity inspection, radioscopic examination, gamma-ray spectrometer assay, fissile material assay, container overpacking (if needed), and data package preparation and review. In addition acceptable knowledge documentation, headspace gas sampling, intrusive examination and chemical characterization data is also used in the final review and certification process.

This paper provides an overview of the contact-handled TRU (CH-TRU) waste NDA/E characterization activities at the INEEL. This effort is currently concentrating on the TRU waste contained in 208-liter (55-gallon) drums stored at the RWMC. The normal process associated with the waste characterization involves a process flow through the SWEPP facility that begins with the drum selection and labeling effort and ends with the data review and quality verification activity. In between the drums pass through a number of inspection and assay stations including a real-time radioscopic system, a neutron assay system, and a gamma-ray spectrometer system. Each step in the process is designed to provide data required for reporting in accordance with the transportation requirements and the acceptance criteria requirements for disposal at the WIPP.

BACKGROUND

Since 1970, the RWMC at the INEEL has served as the major U.S. DOE storage site for defense-generated, CH-TRU waste. Approximately 65,000 cubic meters (2.3 million cubic feet) of CH-TRU waste is stored at the RWMC on above-ground concrete or asphalt pads, either covered with an earthen berm, or inside air support buildings, or in storage facilities which are in compliance with the Resource Conservation and Recovery Act (RCRA) requirements for storage of mixed waste. The waste is contained in approximately 132,000 drums and 11,400 boxes.

Before TRU waste shipments from the INEEL the waste must be characterized and certified to meet the WIPP Waste Acceptance Criteria (WAC) (DOE/WIPP-069). The SWEPP facility was initially developed to evaluate the capability of various technologies to examine the various waste forms and to certify the contents of waste containers for shipment to WIPP. Over the years, the mission of the facility has changed from technology demonstration to production. The current mission of SWEPP is to perform the non-destructive examination (NDE) and non-destructive assay (NDA) of TRU waste contained in drums for shipment to WIPP.

TRU WASTE CERTIFICATION PROCESS

The WIPP Waste Acceptance Criteria (WAC) (DOE/WIPP-069) requires that each site participating in the characterization, certification, and transportation of TRU waste for disposal in the WIPP perform the following functions:

- Perform TRU waste certification program activities as specified in the WIPP Quality Assurance Program Description (QAPD) (DOE/CAO-04-1012)
- Perform TRU waste characterization program activities as specified in the WIPP Quality Assurance Program Plan (QAPP) and certify the WIPP Waste Stream Profile Form data
- Document and certify that all TRU waste payload containers prepared for shipment to the WIPP meet all specified Transuranic Package Transporter-II (TRUPACT-II) Authorized Methods for Payload Control, TRUPACT-II Authorized Methods for Payload Control (TRAMPAC), and WIPP WAC Requirements

- Document site approval of the authorized contents (payload), ensuring compliance with all packaging and records requirements, ensuring that all parameters are met before the package is released to a carrier for transport, and obtaining WIPP authorization to ship.

The WIPP WAC also describes the process for sites to obtain certification authorization for TRU waste characterization, transportation, and certification for disposal in the WIPP. The INELL certification process is described in the INEEL Program Plan for Certification of INEEL Contact-Handled Stored Transuranic Waste (Parker). Obtaining site certification authorization from the DOE-Carlsbad Area Office (CAO) is a multi-step process consisting of:

- Approval of the site TRU Waste Characterization Quality Assurance Project Plan (QAPjP)
- Approval of the site TRUPACT-II TRAMPAC Plan
- Approval of the site Certification Plan
- Approval of the site TRU Waste Characterization, Transportation, and Certification Quality Program Plan
- Demonstration of successful implementation of the plans listed above based on audits conducted by the DOE-CAO.

Comparison of validated characterization data for each waste container to the appropriate WIPP waste acceptance criteria is required for final waste container certification. Characterization data for containers identified as being WIPP-certifiable are transmitted to WIPP via the WIPP Waste Information System (WWIS) where the data are reviewed and approved by WIPP personnel.

DOE-WIPP Requirements

The DOE WIPP requirements for the characterization and certification involve the use of non-destructive assay/ and examination (NDA/E) techniques and processes to acquire the data needed for verification and reporting. Capabilities to certify individual waste forms are dependent upon successful implementation of program requirements described in the WIPP Waste Acceptance Criteria (WIPP-WAC) (DOE/WIPP-069), the WIPP Quality Assurance Program Plan (QAPP) (DOE/CAO-94-1010), the Transuranic Package Transporter-II Certification of Compliance (INEEL/EXT-97-0015), the RWMC Implementation Plan for the TRU Waste Characterization Program (TWCP) (INEEL/PLN-185), and the INEEL TRU Waste Characterization, Transportation, and Certification Quality Program Plan (INEEL/PLN-182). To support the INEEL Program, many studies have been completed and documented to demonstrate compliance with the technical requirements and to assure that data of known quality are generated and reported.

DOE's TRU waste characterization criteria is specified in WIPP-WAC and QAPP. The QAPP identifies the quality of data and techniques required ensuring that the specific objectives associated with the TRU Waste Characterization Program are met. It describes the activities that will characterize TRU waste for disposal at the WIPP facility, including both the managerial and technical aspects of program management and the data quality requirements that facilities must meet. The WIPP-WAC identifies criteria and requirements that regulate the safe handling, preparation, transportation, and emplacement of TRU waste packages in the WIPP repository.

The quality assurance objective (QAO) parameters for waste characterization using NDA methods are as specified in the QAPP and include for example for radioassay systems: precision, accuracy, minimum detectable concentration (MDC), total uncertainty, total bias, completeness, and comparability. The following is a brief explanation of these parameters:

- The precision and accuracy QAO parameters have been developed for the purpose of establishing a baseline capability of an NDA system. The intent of the precision and accuracy QAO is to assess and document system performance under effectively ideal conditions. This approach provides quantitative information with respect to the fundamental capability of the system in absence of measurement interference that complicate the acquisition, interpretation, and reporting of the data (Becker).
- The minimum detectable concentration (MDC) determination is an estimate of an assay system detection limit used as an indicator for an instrument's capability to segregate waste containers between LLW and TRU waste classifications, i.e., segregation at the 100 nCi/g alpha activity concentration level.
- The total uncertainty includes the propagated uncertainties of all corrections and factors applied to the analysis of real wastes to compensate for heterogeneity and matrix interference. There is no limiting value for the total uncertainty; rather the QAO for total uncertainty is limited to the requirement that it be properly calculated and documented for use in describing the reported assay data. The total uncertainty is used to determine whether or not individual assay results exceed specific criteria at set confidence levels.
- The total bias of the RA measurement system is defined as the systematic error component of the total uncertainty. The determination of this systematic error is important to the confirmation of the inventory used for the WIPP repository Performance Assessment (PA). The total bias is determined and documented as part of the uncertainty evaluation for the population of waste evaluated and is compared with the QAPP QAO total bias limit.
- The completeness QAO parameter requires that radioassay data be obtained for 100% of the waste packages characterized for disposal at WIPP. This is achieved by obtaining and submitting data for each drum that will be shipped and disposed at the WIPP facility.

SWEPP NDA/E SYSTEMS

The primary NDA/E techniques being used in SWEPP to examine waste packages are non-destructive radioscopic and radioassay examinations for container contents. These examinations are performed using the real-time radioscopic (RTR), the passive/active neutron (PAN) assay, and gamma-ray spectrometer (GRS) systems. Surveys for contamination, radiation levels, and drum weight are also made at a container weigh station within the facility. Supporting and associated systems include the Drum Vent and Head Space Gas Sampling Facility and the Transuranic Packaging Transporter (TRUPACT) Facility.

Neutron Assay System

The SWEPP PAN assay system was originally designed and constructed by Los Alamos National Laboratory (LANL) and was installed at SWEPP in 1984 and accommodates standard 208-liter (55-gallon) drums (Caldwell).

In the PAN system, the passive neutron unit detects the number of time-correlated neutrons being emitted spontaneously from the waste package. Passive neutron measurements are then used to quantify the spontaneous fission neutron yield of the source material. The passive portion of the measurement records neutrons being emitted spontaneously, using electronic processing that separates neutrons detected in clusters of two, three, or more at a time from neutrons that are detected singly. The cluster events can be related to spontaneous fission of Pu-240. Since most of the TRU waste processed at SWEPP has a constant Pu-240 isotopic fraction, the Pu-240 measurement can be used to estimate the total Pu mass in a waste package. The single events are related to alpha-neutron reactions in the waste matrix, which for

most of the SWEPP wastes are produced by Americium (Am) 241. After processing, this data can be used to estimate the total Am-241 mass present.

Active neutrons are measured by inducing fission in fissile material via an interrogation neutron source and then quantifying the resulting induced fission neutron signal. The interrogation neutrons are provided by a Zetatron neutron generator which produces bursts of 14 MeV neutrons. These neutrons are thermalized and used to interrogate the waste packages and to produce fissions in Pu-239 and other fissile TRU isotopes. The prompt fast fission neutrons that result are counted and can be related to the mass of Pu-239 present.

Wastes originating from the Rocky Flats Plant (RFP) constitute most of the SWEPP inventory. These wastes consist of primarily weapons grade material have a constant ratio of Pu-239 and Pu-240, and thus both the active and passive assay measurements can be used to estimate total Pu mass (East). This allows a considerable amount of cross-checking to be done. Since the active measurement is more sensitive, it is used generally to determine Pu contents below ~20 g, and especially to determine if a package is below the 100 nCi/g "non-TRU" limit.

The SWEPP assay system utilizes GRS data in conjunction with PAN data to determine the nuclear parameter values. Uncertainty values are placed on parameters and propagated through the algorithms to derive the total error on reported values. The measurement uncertainty evaluation for a population of waste is used to determine bias and matrix precision coefficients used in the calculation of the total error associated with each value. The bias and matrix precision uncertainty components are combined with the counting precision errors to derive the total error (reported at one standard deviation) associated with each derived value for each drum assayed (East).

The drum assay PAN unit data generation system consists of the assay chamber and its associated polyethylene and graphite moderating materials, structural aluminum, and steel; drum rotator; vertical door opening and closing mechanism. A Zetatron-type pulsed neutron source; active, passive, and interrogation flux neutron detector packages (both shielded and unshielded); mechanical, electrical, and nuclear safety interlock hardware; and various assay chamber signal acquisition and processing electronics. Also associated with the PAN system is a calibration verification drum (designated the "Pink Drum") containing a californium (Cf-252) source and a depleted uranium (DU) source.

Gamma-Ray Spectrometer System

The SWEPP gamma-ray spectrometer (GRS) system uses passive gamma-rays to analyze radioactive waste packaged in 208-liter (55-gallon) drums. The GRS is a modified Canberra Industries, quantitative and qualitative (Q^2) low-level waste assay system. The (Q^2) shield chamber was modified to accept four detectors. The chamber is constructed of low radiation background steel. Four circular penetrations have been cut into the back wall of the chamber for insertion of the snouts of the four HPGe detectors. The detectors are positioned at different elevations in the shield to provide overlapping coverage of the waste drum. The detectors are nominally 10% efficient and have energy resolution of better than 800 electron volts (eV) at 122 keV.

During radioactive decay, a given radionuclide emits a number of gamma-rays with specific energies. This gamma ray distribution is known as the gamma-ray energy spectrum for the isotope of concern. Measuring the gamma-ray energy emitted by an unknown sample (analyzing the spectrum) identifies the radionuclides in the sample. The GRS is capable of identifying gamma-ray emitters at very low activity levels packaged in a wide variety of matrix materials. Each of the four HPGe detectors in the system detects and records gamma-rays emitted from the waste and generates a gamma-ray spectrum. The individual detector spectra are normalized and summed prior to final processing and analysis by the VAXGAP analysis code (Killian, 1988 and Killian, 1997). Each spectrum is individually validated using the stored pulser information. The

individually acquired spectra are summed together to increase the resolution of the spectral lines and reduce the total count time under low count rate conditions (McIsaac). This spectral summing upgrade reduced the required count time for each drum significantly. The software processes the resulting information in a specific energy region to arrive at calculated ratios of the mass of selected isotopes to the mass of ^{239}Pu and/or to the mass of ^{235}U. The reported isotopic mass ratios assume that the ratios are constant throughout the entire contents of the drum. The isotopic mass ratio data is used in the PAN assay software to verify or adjust the quantitative results calculated by the PAN assay system. Without these measured isotopic mass ratios from the GRS, the PAN assay system assumes the radioactive material to be weapons-grade plutonium which consists of ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, and ^{241}Am (a decay product of ^{241}Pu) in nominal weapons-grade proportions. Because of the variety of chemical separation processes used by the waste generator, the material in a drum may not be entirely weapons-grade plutonium. If the contents are found to be enriched in ^{241}Am and/or ^{235}U, then the isotopic mass values obtained by use of the PAN assay system alone would be in error.

The system includes a shielding enclosure, drum turntable, turntable motor, motor controls, high-resolution high-purity germanium (HPGe) detectors, associated amplifiers, high-voltage power supplies, analog-to-digital converters, acquisition and interface modules, the calibration pulsers, the Ethernet communication link, and a VAXstation computer. Also included is the liquid nitrogen (LN) support system required for operation of the HPGe detectors and a drum containing four $^{152}Eu_{52}$ sources for energy calibration of the system.

Real-Time Radioscopy System

The Real-Time Radioscopy (RTR) waste NDE system uses an X-ray source and image intensifier (radioscope) to allow the image of the object under examination to be displayed at the same time the examination is taking place (i.e., in "real" time). This is especially desirable in the identification and characterization of radioactive or hazardous waste because container contents can be examined without breaching the container. The system also provides digital data and image recording capabilities.

The real-time X-ray radioscopy system is used to determine or verify the proper waste Item Description Code (IDC) and visually examines the contents of the waste containers to determine if the contents meet certain waste form requirements. Information on the presence of liquids, gas cylinders (e.g., aerosol cans or other potentially pressurized containers), etc. is provided using the RTR system.

The X-ray tube head is a Philips Model MCN 421 X-ray head with a maximum tube operating voltage of 420 kVp dc. A beam focus selector for the tube head may be set on wide or narrow focus. The imaging system consists of an image intensifier, high-resolution charged-coupled device (CCD) camera and a digital X-ray video processor. The digital video processor captures images in real time and can enhance critical or low contrast features of an image through a variety of image enhancements, filters, and real-time frame averaging hardware and software to improve signal-to-noise resolution. The output of the imaging system is supplied to a monitor at the operator's station and a real-time digital video is made of each drum examined, which includes the operator's voice comments with respect to observations during the examination. The video is stored on optical media which provides the following benefits; video duplicating with no loss of image quality, no degradation of video quality over time, random access to all examinations, and a highly stable media for archival storage.

DATA MANAGEMENT

Effective management of data collected at all characterization stations is required to meet WIPP requirements. Validation and verification of data are performed at three different levels: data generation, data verification and reporting, and final verification. Level I validation and verification occur at the level

of data generation, such as the RTR or headspace gas sampling station. Level-I validation is more detailed than either the Level-II or Level-III reviews and requires expertise with the process generating the data. At Level I, release of data requires signature releases from a qualified independent technical reviewer, a technical supervisor, and a QA officer. The independent technical reviewer must be qualified to have performed the initial work. This person ensures that the data are technically correct, complete, within established control limits, and that variances from accepted methods are adequately documented. The technical supervisor ensures that the data are technically reasonable, complete, and have been through independent review. The QA officer ensures that the independent technical and technical supervisor reviews are complete, appropriate QA documentation is complete, and that the program QA objectives have been met. To ensure consistency, these checks are performed in accordance with procedures and documented through the use of checklists.

For example RA data generated in the SWEPP facility for each drum assayed undergoes a technical assessment and review (physics review) process as described in Nondestructive Assay (NDA) Data Assessment and Technical Review Process (Twedell). The NDA data assessment and review process is predicated on understanding the operational capabilities of the SWEPP assay system as a function of the waste form being assayed. RA data collected by the PAN and GRS systems are evaluated against established criteria and are reviewed for anomalies by personnel knowledgeable in the SWEPP assay systems, and RA requirements, the waste characteristics, and the expected source materials in the waste. Comments are provided for any review criteria not met or anomalies observed in the data. The NDA reviewer releases the RA data by signature providing evidence that the reviews have been performed.

Level-I data are transmitted to the Site Project Office (SPO) for further validation, reconciliation, and storage. Processing these data at the SPO represents Level-II validation. Level-II data validation confirms that the data generation level validation was conducted appropriately and evaluates sampling batch quality control (QC) checks that require information from more than one facility. A general review that looks for completeness and acceptability of the data as reported is also performed. On a periodic basis, the project office conducts a repeat of the Level-I validation for each of the facilities to ensure that the implementing procedures at the facility level are adequate. Activities include reconciliation of waste stream data quality objectives, and preparation of the WIPP waste stream profile form. Reconciliation of the data requires summarizing specific types of data for a waste stream and determining if enough data have been collected to characterize the waste stream and to meet some specified data quality objectives.

The SPO Manager reviews the data and decides if sufficient data have been collected for the waste stream. If sufficient data have been collected and meet all required parameters, a waste stream profile form can be generated. The waste stream profile form uses acceptable knowledge documentation (INEL-96/0280) and data generated during the characterization/reconciliation process to describe a waste stream. Data released from the SPO to WIPP include a signature release from the site Project Manager and the Site QA Officer (SQAO). These signature releases ensure that the data have been Level-II validated and properly reconciled for the waste stream.

Level-III validation of waste characterization data occurs at WIPP and is essentially an inventory check to ensure that the data received are complete. Additional checks may occur to ensure that data have been appropriately reconciled.

A primary and fundamental part of TRU waste storage, characterization, transportation, and certification is managing waste container information. The existing legacy Data Management System (DMS) and associated information systems are currently being replaced by the Transuranic Reporting Inventory Processing System (TRIPS). TRIPS will electronically integrate the current hard copy of TRU waste data collection, validation, and certification process (both automated and manual) that exists, ensuring that users can readily access characterization, transportation, and certification information. TRIPS will provide an

electronic capability to collect characterization data from geographically dispersed locations, increase the speed and efficiency of the data review process, and provide reporting capabilities to WIPP via the WWIS. Additionally, TRIPS will support other key TRU waste operations activities such as container tracking, inventory control, and certification process status. TRIPS is being designed in compliance with American Society of Mechanical Engineers (ASME) Nuclear Quality Assurance (NQA) - 2a, Part 2.7 requirements, and will provide capabilities to support the following certification process operations:

- TRU waste storage and inventory information
- TRU waste characterization and certification process support
- TRU waste payload assembly decision and documentation support
- TRU waste reporting and certification documentation
- Electronic review and approval of characterization, transportation, and certification data
- Provides the necessary WWIS interface to transmit data to WIPP, and receive authorization from WIPP personnel to ship TRU waste for disposal.

TRIPS is currently being implemented in a phased approach to avoid schedule impact on production operations, and is expected to be fully operational by December 1998.

SUMMARY

The RWMC/SWEPP facility is in full production operation processing in excess of 100 drums per week of TRU waste and collecting and storing the required data for characterization and eventual shipment to WIPP for disposal. Continuing waste characterization software development and the implementation of identified upgrades are expected to increase both process efficiency and the percentage of certified waste containers.

The INEEL has successfully implemented capabilities and requirements to support production-level TRU waste characterization, certification, and transportation operations for shipment of waste to WIPP. Current program status includes:

- DOE-CAO approval of INEEL top-tier program documents
- Successful participation in the DOE-CAO Performance Demonstration Program for headspace gas sample analyses, solidified waste core sample analyses, and radioassay systems.
- SWEPP radioassay systems have successfully passed the testing associated with the WIPP radioassay Performance Demonstration Program Plan (PDP) for the TRU Waste Characterization Program evaluation cycles 1, 2, 3, and 4
- Transportation certification authorization from DOE-CAO to use TRUPACT-II since April 1992
- Acceptable knowledge documentation for Rocky Flats Plant-generated wastes
- Restart of production-level TRU waste characterization activities in September
- Participation in TRU waste certification audits by DOE-CAO
- Final certification authorization expected in March 1998.

The INEEL is currently staged to process a minimum of 4,500 drums per year needed to meet initial requirements of the Settlement Agreement between the State of Idaho, Department of the Navy, and the DOE. Initiation of shipment of stored TRU waste to WIPP will begin once WIPP is opened and authorization to ship is received.

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KEY WORDS

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