Development of Non-Destructive Characterization Systems for Large Boxes Containing Transuranic Waste

R.A. Nelson
Carlsbad Field Office, U.S. Department of Energy
P.O. Box 3090, Carlsbad, NM 88221
USA

J. De Gregory, C. L. Nalezny
Office of Environmental Management, U.S. Department of Energy
1000 Independence Avenue, SW, Washington, DC 20585
USA

ABSTRACT

About 25% of the retrievably stored legacy transuranic (TRU) waste at DOE sites across the country consists of large boxes greater than about 120 x 120 x 150 cm. The TRU waste disposal program at the Waste Isolation Pilot Plant (WIPP) was originally based on use of cylindrical shipping containers that are not compatible with this waste form geometry. DOE began design of a new shipping container to accommodate large boxes and simultaneously initiated a research and development program for characterization systems that could meet WIPP requirements. This paper describes R&D for non-destructive assay (NDA) and non-destructive examination (NDE) equipment that could be certified within the strict WIPP regulatory envelope for characterizing the contents of large boxes. These systems will allow the direct disposal of large boxes, and avoid the cost and potential worker exposure of repackaging into smaller containers.

R&D for NDA led to a 2-part system with a passive neutron counter with an add-a-source matrix correction capability, and a physically separate gamma counter for isotopic characterization with a transmission correction capability. These very large nuclear counting systems are described.

R&D for NDE led to a unique software-hardware machine design. A 3-MeV linear accelerator (Linatron®) generates highly collimated bremsstrahlung photons directed through the large boxes. Two detectors are employed to digitally survey the entire box interior. A linear diode array scans by moving the box on an elevated table with three degrees of freedom (y,θ,φ). Alternately, an area detector array images (real time) interior volumes with further beam collimation. The Linatron® and area detector separation and box position are robotically synchronized to keep imaged objects centered at constant magnification during examination.

Initially, the NDA and NDE systems are being installed at the Savannah River Site (SRS). Acceptance testing and operation at SRS are planned for most of 2006. It is expected that experience gained in screening operations will allow these characterization systems to be fully certified under WIPP's regulatory framework in early 2007.

INTRODUCTION

For the past 15 years, the baseline plan for shipment of retrievably-stored defense-related transuranic (TRU) waste across the Department of Energy (DOE) complex to WIPP has been based on payload containers that could be accommodated by the TRUPACT-II (Transuranic Packaging Transporter Model II). The TRUPACT-II is a Type B shipping container certified by the Nuclear Regulatory Commission (NRC), with an inner payload capacity of about 5 m^3 and cylindrical payload geometry (Ø184 cm x 190 cm high). Routine payload configurations currently used in shipping to WIPP include 7-pack (six drums surrounding a central drum) assemblies of 208 liter drums, standard waste boxes, assemblies of three 378 liter drums, etc. All of these are compatible with the cylindrical configuration of the TRUPACT-II. The most common container of retrievably-stored TRU waste across the complex is the nominal 208 liter drum.

However, about one fourth by volume of the retrievably-stored waste is contained in large rectangular boxes varying in size from about 120 x 120 x 150 cm (W x H x D) to more than several meters on each side. Table 1 shows the most current inventory of TRU waste in rectangular boxes by site (stored and projected). Until recently, the disposal plan for waste in large boxes at each site was to open the boxes, and re-package the waste into payload containers compatible with the TRUPACT-II.

Table I. Number and Total Volume of Large Rectangular Boxes at DOE Sites

Site	**Total Volume (m^3) of Boxes**	**Total Number of Boxes**
Hanford	7,955	668
Idaho National Lab	36,878	11,332
Los Alamos	6,576	890
Lawrence Livermore	166	31
Nevada Test Site	270	58
Oak Ridge	410	83
Savannah River	4,512	332
Others	841	136
Total	**57,608**	**13,530**

Re-packaging large boxes into smaller containers that can be shipped in the TRUPACT-II requires significant effort and worker risk. Since the boxes are too large for typical glove-box operations, opening and mining the boxes must otherwise be done manually in a confinement structure. Fig. 1 shows such a repackaging effort at the Los Alamos National Laboratory. This presents unique challenges in worker protection and contamination control. Without resorting to some sort of volume reduction (such as compaction which presents its own set of issues), re-packaging also typically results in an increase in total waste volume.

To improve the baseline plan for the large boxes, DOE has initiated an effort to develop a new shipping container that will accommodate the majority of the large boxes in the inventory. Known as the TRUPACT-III, it will be a rectangular Type B shipping cask, and certified by the NRC (estimated Fall 2007). In concert with the development of the TRUPACT-III, DOE is also developing the capability to characterize large boxes in a way that may preclude the need for re-packaging into smaller containers. This paper describes the research and development process leading up to the planned deployment of large box characterization systems at the Savannah River Site in 2006.

The requirements for characterization of TRU waste for shipment to WIPP are established through the WIPP Waste Acceptance Criteria (WAC) and Waste Analysis Plan (WAP). The WAC requirements derive roughly from conditions placed by safety analysis or authorization basis requirements, and the Environmental Protection Agency (EPA) and the NRC in their approval of WIPP operations and transportation. The WAP requirements are part of the Hazardous Waste Facility Permit (HWFP) conditions issued by the state of New Mexico pursuant to their authority regulating hazardous materials. While there is some overlap in the WAC and WAP, the WAC requirements are generally met through non-destructive assay (NDA), and the WAP requirements are generally met through non-destructive examination (NDE) of the waste containers destined for disposal at WIPP.

Fig. 1. Repackaging large boxes with size reduction presents special risks.

RESEARCH AND DEVELOPMENT - AN ALTERNATIVES PROJECT

The NDA and NDE systems employed to characterize drummed waste (and even standard waste boxes) meeting WIPP WAC and WAP requirements have become almost commonplace. After the regulatory requirements for characterization matured in the late 90's, various systems were evaluated and certified to meet those requirements. At first blush, it might seem that the characterization of large boxes was only a matter of scale. In principle, it would seem that the same instruments employed for characterizing drums could just be scaled up by a factor of 3-4, using the same physical methods. For NDA, the gamma and neutron detectors could simply be made larger, with more of them to cover the larger fiducial volume. For NDE, the x-ray intensity could simply be increased (potentially with a slower scan rate to allow operator interpretation of the larger images). However, while the linear scale increase from drums to large boxes is only a factor of 3-4, the volume and weight changes increase by the cube of the size (27-64). In addition, the possibility of significant objects in the boxes that could confound both NDA and NDE instruments made it likely that different methods would need to be developed.

The Office of Technology Development and Demonstration, Alternative Projects Program was established to provide alternatives to the baseline technologies and processes that have the potential for improving performance, reducing costs and schedule with technically viable alternatives or step improvements to the current baselines. The targeted site baselines were selected with input from site and Headquarters managers, and consisted of a small set of high-impact projects focused on specific site baselines or site problem sets with high cost and/or high technical or programmatic risk. An Alternatives Project must provide a technical option that could be inserted into a site program within the required timeframe of the site cleanup schedule, and must be fully endorsed by the site project manager and integrated within the existing scope and schedule of the site project.

In 2003, an Alternatives Project was initiated by the DOE Headquarters (HQ) Office of Technology Development and Demonstration in the Office of Environmental Management, in concert with the Carlsbad Field Office (CBFO, the field office managing WIPP operations) and SRS. An Acquisition Plan was developed that called for a 3-phase research, development and deployment program. Phase I was designed to fund multiple instrument developers to model and test conceptual designs of instruments that could meet WIPP WAC and WAP requirements. Separate requests for proposals were solicited for NDA and NDE systems. Proposals were received from several firms, which believed compliant systems could be developed. The procurement was conducted as a Program Research and Development Acquisition (PRDA), which set out the criteria for evaluating the Phase I results and established the process for down-selection to Phase II. Coincidently, the procurement and contracting functions for the HQ Office of Cleanup Technologies were assigned to the SRS contracting organization (SRS is responsible for all Alternative Projects contract functions).

At the end of Phase I, the competing designs for NDA systems were evaluated to assess the likelihood that each conceptual system (or systems) would be able to achieve WIPP certification under the stringent requirements imposed by the WIPP regulatory envelope. A similar evaluation was conducted for the competing NDE system conceptual designs in parallel. Two developers were down-selected to enter Phase II of the project according to the criteria established in the original PRDAs.

Phase II called for each of the successful developers (one for the NDA system and one for the NDE system) to construct, test, optimize and finally deploy their respective instruments at SRS. Because of the largely unknown requirements of each system for infrastructure support at SRS, the site interface requirements established in the original PRDA (at the beginning of Phase I) were extremely general in nature.

While the R&D process has focused on characterizing large boxes, the ability to process other waste payload containers would make the systems more flexible. To this end, the developers have incorporated the ability to assay and examine 208, 322 and 378 liter drums, standard waste boxes (1.88 m^3) and ten-drum over-packs (TDOP, 4.5 m^3). However, the primary intent is for characterization of boxes that have been packaged into what is called the Standard Large Box (SLB-2), which is a new WIPP payload container specifically designed as the primary payload in the TRUPACT-III. The SLB-2 and TRUPACT-III design calls for a maximum net payload weight of 5,100 kg, with SLB-2 interior dimensions of 160 x 160 x 260 cm (Fig. 2).

Fig. 2. Standard large box (SLB-2); the payload container for the TRUPACT-III

At this time, both of the developers are nearing the end of Phase II, and the systems are in varying stages of deployment at SRS. Once the systems have been accepted, Phase III efforts will involve using the systems to screen large boxes, and eventually lead to WIPP certification. Acceptance testing will assess the ability of each system to assay or examine surrogate waste containers containing known materials in various matrices and container configurations. Under the provisions of the PRDA contracts, the acceptance tests only evaluate each system's functionality. The degree that each system passes its acceptance test weighs heavily in the contract award fees which will be earned by the Phase II developers.

NON-DESTRUCTIVE ASSAY SYSTEM DESCRIPTION

The NDA System is comprised of a gamma scanner and a passive neutron counting system (Fig. 3). These two physically independent assay systems are mounted within separate ISO containers, but connected via Ethernet to allow automated integration of the assay results from the two systems. In operation the waste containers are first assayed within the gamma system to obtain both quantitative gamma-ray assay results and relative isotopic data. The container is then moved to the neutron assay system. Results from both assay modes are reviewed to select the most reliable assay result. The target waste stream includes a wide range of waste matrices (e.g., metals, sludge or debris) and isotopic mixtures including weapons grade or heat source plutonium, some enriched in Am-241 only, or containing uranium, and mixtures of these. The system was designed to provide the ability to segregate wastes at the 100 nCi/g level and quantify wastes for WIPP disposal in both assay modes. While installation and testing are yet to be completed, it is expected that analysis times of large containers that meet the WIPP WAC will require about 1 hour each in the gamma counter and passive neutron counter (i.e., ~4-5 large containers per day could be assayed).

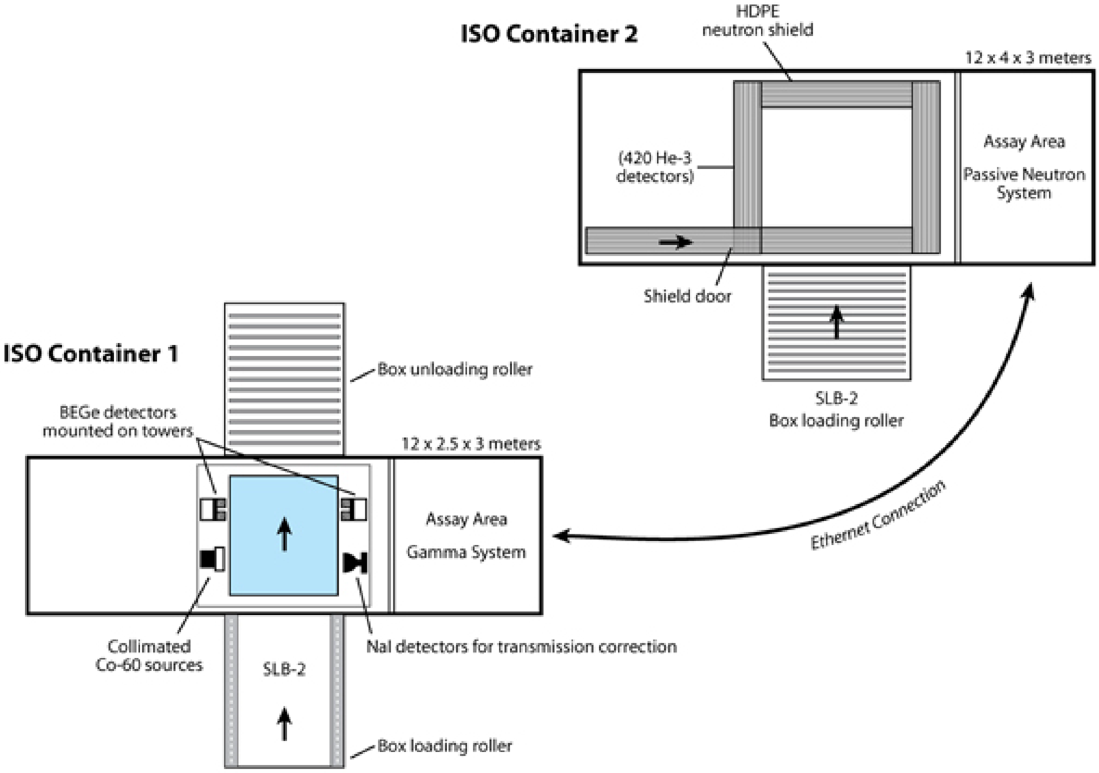

Fig. 3. Block diagram of the non-destructive assay systems

Description of the Gamma Counter

The proposed system contains a total of four shielded coaxial broad energy germanium detectors (BEGe) mounted two each on two towers. One detector tower is located on each side of the container to be measured. Each tower holds two detectors (additional detector/shield assemblies can be added later) and is attached to a track that allows the tower to be manually moved closer to or further away from the sample. The box (or other assay container) is loaded onto a pallet that moves the sample to each of five predefined assay locations (i.e., segments). Typically, the detectors are positioned symmetrically about the vertical center of the assay container. However, the system can be configured in a number of ways to optimize throughput, measurement sensitivity, spatial acuity, or user convenience. For example, should prior knowledge of the sample indicate that the matrix or source distribution is located in an extreme location, the detectors can be repositioned for a closer examination of the area of interest. Spatial acuity refers to the size of the segments that are being measured. Measurements of smaller segments offer improved accuracy and can better identify hot spots and heterogeneous radioactive source concentrations in the waste containers.

For operation of the counter, the detectors and towers are adjusted to the reference location for the particular container size. The towers permit motorized adjustment of the detector height in the vertical direction to accommodate different container configurations. Detector heights can be adjusted from approximately 30 to 200 cm from the base of the container using an electric drill connected to a special fitting on a gearbox. Separation distance between the towers is also mechanized; both towers are mounted on tracks that allow the detector towers to be moved laterally, increasing or decreasing the separation between the towers. The container is then placed on the conveyor for the measurement.

The assay container moves along the track, stops at preset locations and measurements are performed at each segment along the length of the container. Data are acquired for each segment for a predetermined period of time. To count the SLB-2, the detectors are configured to measure 5 segments on a side providing 20 measurement points. Each segment is nominally 0.5 x 0.8 meter in area.

The BEGe detectors are mounted in a composite collimator and background reduction shield. The shields provide 10 cm of lead in all directions around the detector except for the collimated viewing area; this reduces spectral interference from radium/thorium/potassium background gamma rays, and from non-background sources of radioactivity at the assay site. The collimator limits the field of view of the detectors so that there is reduced 'cross talk' between measurement segments.

In order to assess the matrix heterogeneity of the crate, a set of two Co-60 transmission sources are located directly opposite NaI gamma detectors on the far side of the assay container. Such high-energy gamma sources are used to be able to penetrate widely different matrices. The transmission source shields move in parallel with the gamma detectors to measure the matrix density in vertical and horizontal segments. The transmission sources are installed in thick lead shields assemblies with tungsten shutters to provide safe operation of the counter.

Description of the Passive Neutron Counting System

The neutron counting design is heavily based on the design of the so-called SuperHENC (High Efficiency Neutron Counter) [Ref. 1]. It employs 420 neutron detection tubes containing He-3 (and other quenching gases) at 10 atmospheres embedded in a 30 cm thick neutron moderator/shield of High Density Polyethylene (HDPE). These large tubes (Ø25 mm x 2.5 m long) surround the assay container on all sides (He-3 tubes are also included in the shield door) for 4π geometrical coverage. The assay container is placed on a roller bed, and slides into the assay cavity, and then the shield door is closed.

To characterize and properly correct for matrix effects, the passive neutron counting system uses the Add-A-Source (AAS) matrix correction technique [Ref. 2]. The AAS technique allows adjustment for the effect of the waste matrix on the neutrons emitted within the container. A Cf-252 source (about $3x10^6$ Bq) is introduced into the assay cavity with no container in the counter. The measurement is repeated after the container is loaded and the results compared. The difference in the measured count rates can be used to correct the measured sample rate for matrix effects.

Another benefit of the AAS measurement is the ability to correct the measured coincident neutron background rate for the shielding effect of the matrix within the container. Just as the moderator content of a container decreases the detection efficiency for fission neutrons the background neutron rate is reduced (although by a different factor). If this effect is not corrected, a significant negative bias in the reported plutonium mass can result.

The AAS correction assumes a uniform source distribution. When a point source is placed in an assay container with high moderator content, the positioning effects can be significant. Modeling was performed during Phase I of the Alternatives Project to examine the positioning effects. These results are combined with measured data to characterize the counter response and determine the uncertainty in the measurement, as required for WIPP certification. It has also been found that the AAS measurement can be used to estimate the minimum and maximum response for an assay.

NON-DESTRUCTIVE EXAMINATION SYSTEM DESCRIPTION

The primary requirements that any NDE system must meet for waste characterization for disposal at WIPP include:

- ability to confirm WIPP permitted waste forms i.e., S5000 (debris waste: combustible, metals, etc), S3000 (homogeneous solid), and S4000 (soil/gravel),
- ability to detect a 3.2 mm (0.125 in) diameter hole in a typical aerosol can located at the center of a waste container filled with a variety of waste (e.g., iron, plastic, wood),
- system shall enable the examiner to identify "test items" inside a container, such as coveralls, empty bottle, irregular shaped pieces of wood, empty and full one gallon paint can, aerosol can with fluid, one gallon bottle with three tablespoons of fluid, one gallon bottle with one cup of fluid (upside down), leaded glove or leaded apron,
- system shall enable the examiner to identify "prohibited items" in various waste matrices, such as liquid waste in containers with more than 2.5 cm or 1 percent by volume, sealed containers greater than 4 liters, and pressurized containers, and
- system shall enable the examiner to identify "hazardous items", such as sharp objects or very heavy objects.

In addition, the system must allow these determinations to be made with sufficient X-ray energy to penetrate, at a minimum, 20 cm (7.9 inches) equivalent thickness of steel. It should have sufficient maneuverability to image around large stack-ups of material in order to produce angled views of an object of interest up to and including creating computed tomographic imagery of small containers.

The importance of a single large radiograph for inspecting large containers cannot be understated. An operator's ability to confirm waste forms and to identify the items described above is significantly improved if they can see the entire content of the container at one time and ascertain knowledge of its overall mix. Thus the NDE system was designed to incorporate two scanning modes; an overall image of the entire box volume using a linear diode array (LDA), and a high-resolution real-time image of a small localized interior sub-volume at any point within the box using an area detector array (ADA).

From the R&D testing conducted during Phase I, it became clear that a conventional (~ 450 kV) industrial X-ray source would not be sufficient to penetrate the large containers required by this program. For example, it was conclusively shown that conventional x-ray sources were unable to quickly image a 3.2 mm (a 0.125 in) hole in an aerosol can behind many inches of steel. Similarly, the real-time imaging of containers for determination of the presence of liquids (i.e., sloshing) was not consistently possible. For the large containers to be shipped in the TRUPACT-III, a significantly higher x-ray energy was clearly required.

The conceptual design down-selected for Phase II is schematically illustrated in Fig. 4. Notice the scale of the device.

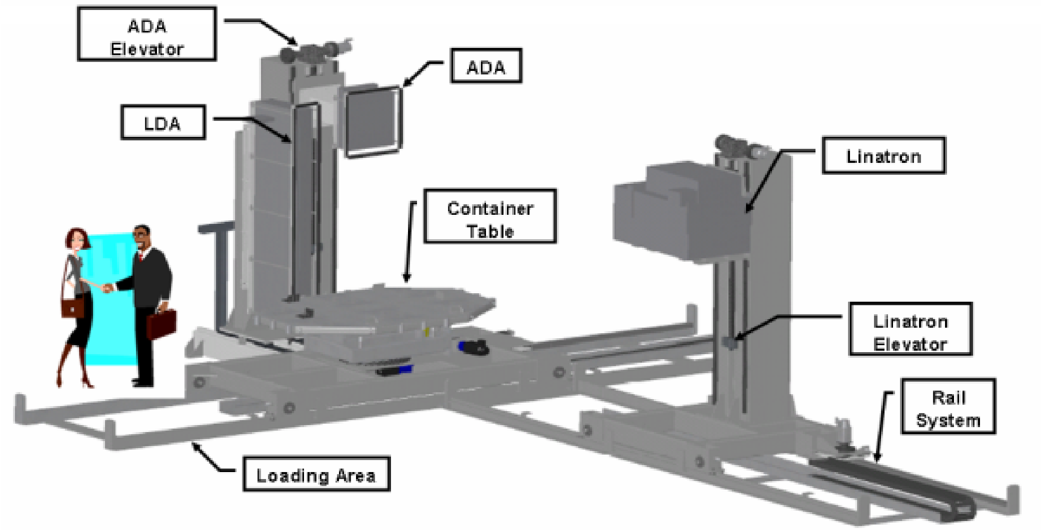

Fig. 4. Schematic layout of the Non-Destructive Examination System

The major subcomponents of the NDE system include:

- 3 MeV linear accelerator X-ray source (made by Varian) to provide adequate penetration and flux for high signal-to-noise ratio. The Linatron® is capable of delivering a dose of 3 Gy/min at 1 meter. However, the expected nominal operating range will be about 10%, or 0.3 Gy/min at 1 meter,
- high-resolution, 5 mm (0.2 in) x 2.5 m (96 in) long linear detector array (LDA) to produce high-detail, high-sensitivity images of the entire container,
- amorphous silicon digital X-ray detector (made by Varian) for large area, distortion free, high-resolution (194 µm pixel size), real-time imaging of localized areas (40 x 30 cm). A standard (low-kV) commercial ADA was modified for use at mega-volt energies and incorporates a thick cesium iodide (CsI) scintillator for improved stopping power, and robust shielding to extend the life of the detector electronics, and
- robotically controlled handling system coupled to the image acquisition software to allow scanning of the entire container.

The ultimate goal of this inspection system was that it be an easily operated system, not a collection of disparate subsystems each requiring separate control and attention by the operator. The Phase II R&D also involved the actual engineering, design, fabrication and installation of a complete system at Savannah River Site, and completing the procedure and technique development for scanning large containers.

One issue that took considerable coordination with SRS to resolve was the tradeoff of space versus shielding for operation of the system. This decision drove the facility infrastructure requirements and how the low leakage head of the linear accelerator was designed. A Monte Carlo analysis of the final design was completed to ensure the design met all personnel exposure limits. In addition, the thick CsI scintillator was optimized for use with the amorphous silicon area detector to provide improved real-time imaging at the lowest X-ray flux rates possible.

The installation at SRS was chosen to minimize the amount of new construction (for shielding) needed. At SRS, previously constructed low activity waste vaults were available. With 60 cm thick (typical) concrete walls and roof beams, and with their large size (about 12 m wide x 45 m long x 7 m high), it was relatively easy to convert one available vault into a large container NDE facility. Two trailers (one for equipment and Linatron® electronics, and one for the operators and imaging electronics) were installed outside the vault, and cabling was run to connect to the scanning platform and the many safety interlocks, cameras and radiation detectors installed throughout the examination area for remote operation.

Operation of the system follows:

1. The payload container is first brought into the X-ray area by forklift and placed on the container cart which has been moved to the side for access.
2. The container is secured to the container cart by means of tie-down straps.
3. When the area has been cleared and secured, and is ready for X-ray operations, the first procedure is to run a fully automated medium-resolution scan of the entire payload container using the 5 mm LDA. This is accomplished by translating (left/right) the container in front of the LDA. Scan times are approximately 1 minute.
4. With the digital image from the LDA scan as a guide, the operator can select an object of interest on the LDA image and the robotic manipulator automatically positions the X-ray source, ADA and container such that the item is centered in the ADA image. The operator then employs various modes of the ADA to interrogate the item at up to 388 μm (0.015 in) resolution and up to 30 frames per second for real-time viewing.
5. If the operator needs to rotate the view around the item under interrogation, the steps are as follows:
    a. First the operator takes two views at approximately +/- 10 degree (horizontal) views.
    b. The system then calculates where in the container the item is located and sets that coordinate as a center of rotation point (tool point) for the robotic manipulator.
    c. The operator can then manipulate the container around that point which keeps the item of interest centered in the ADA image.
    d. Once the item has been dispositioned, the operator selects the next item of interest and the localized viewing procedure begins again.
6. Finally, the container is dispositioned, and removed from the scanning system.

In order to balance the need for a large area, high resolution, real-time detector with a X-ray source that minimizes radiation exposure potential to both operators and electronics, a novel scintillator was employed in a commercial amorphous silicon array that uses individual 388 μm

(0.015 in) CsI crystals approximately 1 cm (0.4 in) thick. This scintillator allows the Linatron® to run at much lower flux than for a typical gadolinium oxysulfide screen [Ref. 3] because of the increased efficiency of conversion at the higher photon energy.

Other than the sheer scale of the system, and the robust electromechanical requirements, the greatest challenge faced with imaging in the proposed system was the amount of flux needed to obtain good signal in the ADA, while keeping the radiation exposure potential as low as possible. The extremely small pixels require significantly more flux than the 5 mm pixels of the LDA [Ref. 4]. Additionally, the faster the detector is operated, the less integration time is available and the worse this condition gets, so the most challenging aspect of the NDE research and development was the design for real-time viewing with the large area detector.

The system has been designed to handle all large waste containers including: SLB-2, standard waste box, TDOP, as well as the standard drum payload containers shipped in the TRUPACT-II. For each payload container type, tie-down fixtures and procedures were developed. While the total imaging time per container will vary depending on the contents that must be identified, it is expected that the majority of imaging time will be spent in the focused ADA mode. An average production rate of more than 2 containers per day is expected, with an average x-ray on-time per container of about 2 hours.

FUTURE PLANS

Installation of the large box NDA and NDE characterization systems will take place through early spring 2006, in parallel with the development of the authorization basis for their operation. With the authorization basis approved, acceptance testing will follow. The large box systems will be used to assay and examine surrogate waste containers containing known amounts of materials in a variety of waste matrix modules arranged in a complex distribution within a SLB-2. For the NDA acceptance test, radioactive sources used in calibration of drum systems will be configured within surrogate waste matrices inside an SLB-2. These matrices will challenge the NDA systems due to their size, complexity and self shielding (both gamma and neutron) character. Both non-interfering and interfering matrix tests will be performed. Non-interfering tests will assess the system's ability to determine isotopic compositions and compliance with the calibration confirmation limits. Interfering tests will assess the systems' ability to accurately assay uniform and non-uniform source distributions approximating the radiation transmission characteristics expected in SRS waste. The system's minimum detectable activity will also be determined using an interfering matrix. The matrix characteristics will match the SRS mass weighted average characteristics as closely as possible (~17 wt% combustible with a total density of 0.23 g/cm^3). Other tests will assess the equivalence of matrix corrections, the stability of the NaI detectors versus count rate and temperature, and the stability of the neutron detector background.

For the NDE acceptance test, 16 surrogate waste drums were prepared, containing materials representative of SRS TRU waste. The inventory of each drum was documented in the form a written log and videotape. These drums will be over-packed into a SLB-2. During acceptance testing, an independent team will review the Acceptable Knowledge information about the drums, examine the drums within the SLB-2 using the large box system, and create records of the drum examination. The record of the examination will be compared side by side with the contents inventory of each of the over-packed drums.

It is expected that routine screening operations of large containers will not begin until sometime in early summer of 2006. The Central Characterization Project (CCP) operated by WIPP for the benefit of other DOE sites (including SRS) will be responsible for operating the large container NDA and NDE systems. Once acceptance testing has been completed, CCP will begin screening operations, which will provide experience in just how well these systems can be expected to perform in a routine characterization environment. Screening operations will separate those large boxes that will need remedial action to remove prohibited items from those that may proceed into Phase III, Certification.

In the spring of 2007, CCP will begin processing (using both NDA and NDE systems) those large boxes that successfully pass screening operations. It is planned that an adequate inventory of large boxes will be processed and that certification audits with participation by the EPA and the state of New Mexico will lead to both systems being certified to meet WIPP requirements shortly thereafter. This will coincide with TRUPACT-III availability (after certification by NRC) planned for late 2007, and allow the initial shipments of large boxes to WIPP. Obviously, the disposal requirements at WIPP still must be worked out, but that is a separate topic, and not described herein.

CONCLUSION

The baseline plan for disposal of TRU waste in large containers around the DOE complex has been to open the boxes, and re-package the waste into payload containers compatible with the TRUPACT-II. If the Alternatives Project to develop the large container NDA and NDE systems at SRS is successful, and they can be certified for characterizing waste destined for disposal at WIPP, then the baseline plan at other sites may be changed. It is possible that similar large box characterization systems could be deployed at other sites (especially at Hanford and Los Alamos National Laboratory) to take advantage of this new capability. Since the greatest number of large boxes is at the Idaho site, it may be worthwhile to consider introducing the large box system capability there as well. For those boxes that can be screened with no requirement to remove prohibited items, the large box systems could significantly improve box throughput at the Advanced Mixed Waste Treatment Plant.

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