TRU DRUM NDE AND NDA WITH THE WASTE INSPECTION TOMOGRAPHY MOBILE TRAILER

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ABSTRACT

The Waste Inspection Tomography (WIT) mobile trailer was developed and is operated by the Waste Inspection Technology Company (WITCO). WIT is designed for the unique characterization of transuranic (TRU) waste drums by performing high-energy 2 MV x-ray NonDestructive Examination (NDE) and gamma NonDestructive Assay (NDA). WIT provides for drum characterization through x-ray inspection of drum content and gamma assay determination of entrained radioactive isotopes using active and passive tomographic principles for all waste matrices. In the summer of 1998, WIT was deployed at the U.S. Department of Energy Nevada Test Site (DOE NTS) to perform its first commercial TRU drum characterization service for the DOE. The road to WIT commercialization involved an 8-year effort focused on supplying services to the DOE with the new WIT technology. This paper describes the path taken to achieve WIT commercialization with the DOE. This effort started in 1990 with a DOE Small Business Innovative Research (SBIR) grant designed to determine the feasibility of using Computed Tomography (CT) to inspect nuclear waste drums. The SBIR grant results were used in a proposal to the DOE Environmental Management Office of Science and Technology (EM-50) for the adaptation of existing medical x-ray CT technology from the proposer, Bio-Imaging Research, Inc. (BIR) and included the technology transfer of LLNL developed CT gamma assay techniques. Two EM-50 cost shared support contracts resulted in WIT trailer development and field-testing. These contracts were designed to develop BIR into a privatized commercial source for the DOE required services. The DOE SBIR and both EM-50 contracts with BIR all originated from competitively bid solicitations. WIT developed practical field experience with deployments at 3 DOE sites and one commercial site including LLNL, RFETS, INEEL, and B&W. WIT successfully participated in a number of DOE sponsored inter-comparison performance test programs including the RCI, CEP, and PDP. WIT performance was verified through a competitively bid cooperative agreement from a Rapid Commercialization Initiative (RCI). The RCI team of verifiers included the DOE, EPA, Army Corps of Engineers, and numerous state environmental regulators who prepared a verification statement. BIR won the SBA Tibbitts award for WIT innovation and economic development as an Illinois company. WIT participated in another competitively bid cooperative agreement for a DOE mobile vendor approval program designed to achieve quality assurance through audits to meet the DOE requirements for TRU waste drum disposal at WIPP. Recently, WITCO joined a commercial team of companies, " the TRUtech team". TRUtech and WITCO supply DOE with all of the required TRU drum WIPP certification technologies which resulted in the competitively bid NTS characterization services contract which included DOE "approvals" of WIT NDE and NDA technologies.

INTRODUCTION AND A DESCRIPTION OF WIT

The mobile WIT trailer utilizes slice plane (tomography) analysis techniques for both NDE x-ray examinations and NDA gamma assays of 55-gallon (208L) nuclear waste drums. The vast majority of nuclear waste drums in the DOE complex are 55-gallons. However, WIT has the ability to inspect up to 110-gallon (416L) waste drums each weighing up to 1,600 lbs. (726kg); thus allowing for the overpacking of 55-gallon drums. The WIT trailer is self-sufficient, turnkey, and includes its own electrical generation (80kw diesel generator) and communication capabilities with cell phones, fax/modems, and local area networked (LAN) computer connections. Shore based power and communication hookups are also available on-board WIT. WIT's HVAC environmental systems allow desert and summer as well as winter and northern climate operations. To date, WIT has traveled over 15,000 miles with field operational experience at 4 DOE sites and one commercial site and has twice traveled coast to coast. WIT's nuclear waste drum inspection experience has included real Low Level , TRU, Mixed Waste and a wide variety of surrogate or phantom waste drums. WIT has thus far inspected mostly 55 and 85 gallon nuclear waste drums. The WIT system field operational experience has thus far been at the Lawrence Livermore National

Laboratory (LLNL), Rocky Flats Environmental Technology Site (RFETS), Idaho National Engineering and Environmental Laboratory (INEEL) , Babcock & Wilcox(B&W)-Lynchburg, and at the Nevada Test Site (NTS). All of the WIT technology and operational procedures have thus far been aimed at satisfying the DOE National Transuranic Program requirements for NDE and NDA. Figure 1. is a pictorial display of WIT hardware. The trailer has four rooms (control, scanner, equipment, and storeroom). The trailer weighs 87,000 lbs. when fully assembled and has 3 axles with air-ride suspension. With weight reduction through the removal of portable radiation shielding, the WIT trailer can travel in all 50 states with weight and size permits. With a 13 foot exclusion zone around the trailer, radiation levels are less than 2mR/hr outside the exclusion zone and less than 1 mR/hr inside the trailer control room during 2MV NDE operation. The WIT trailer includes over 24,000 lbs. of radiation shielding for the 2 MV high-energy radiation source. Its computer room has 6 networked computers (scanner control, NDE image processing, NDA spectroscopy processing, radiation monitoring, data spooling with printer control, and report generation). The trailer has 2 motorized drum loading/unloading doors, the 3-axis motorized drum manipulator includes precision drum rotation, tilt, and elevation. The scanner has 6 motorized motions for elevation and translation of the HPGe detector, the isotopic transmission source and the gamma cameras. Both the 2 MV Linatron and the x-ray detector array are stationary devices generating a horizontal fan-

Figure 1. Four Photographs of WIT hardware: (at the right) including: the trailer (top), the computerized WIT control room (middle), forklift drum loading, (lower left), a rotating and elevating real TRU drum with a single HPGe detector (lower right)

beam of x-rays that can penetrate a rotating, tilted, and or elevating drum.
There are three detection systems on-board WIT. They include a linear array 864 channels of solid-state x-ray detectors used for NDE with 2 MV (@ 200 rads per minute at 1 meter) for Digital Radiography (DR) and Computed Tomography (CT). DR produces a freeze frame x-ray projection image of an entire drum while CT produces x-ray slice plane images of drum content. There are two gamma cameras on-board each with 11 x 14 inch solid Sodium Iodide crystals and 55 photo-multiplier tubes. These cameras can rapidly identify the location of gamma hot spots in the drum in 2-D and in 3-D using emission tomography techniques. The third detection system onboard WIT, used for NDA, is a High Purity Germanium (HPGe)

detector with 1.45 mCi of Ho-166 as an active transmission isotopic source. This detector and source are respectively used for WIT spectroscopy and assay with techniques called Collimated Gamma Scanning (CGS) and Active and Passive CT (A&PCT). Both were NDA techniques developed by LLNL.

Figure 2. Three Typical WIT NDE Images: Lower left is an LLNL TRU drum image from a WIT 2MV DR of 20 grams of ^{239}Pu in a cemented 5-gallon pail inside a 55-gallon drum. The lower right is a WIT 2 MV CT slice through the 20 grams of ^{239}Pu. The WIT image on the right is the 3-D 2 MV CT volume rendering of TRU INEEL sludge in a 55-gallon drum showing the upper lower density sludge as lumped compared to smoother lower cement shown below the lower drum rib.

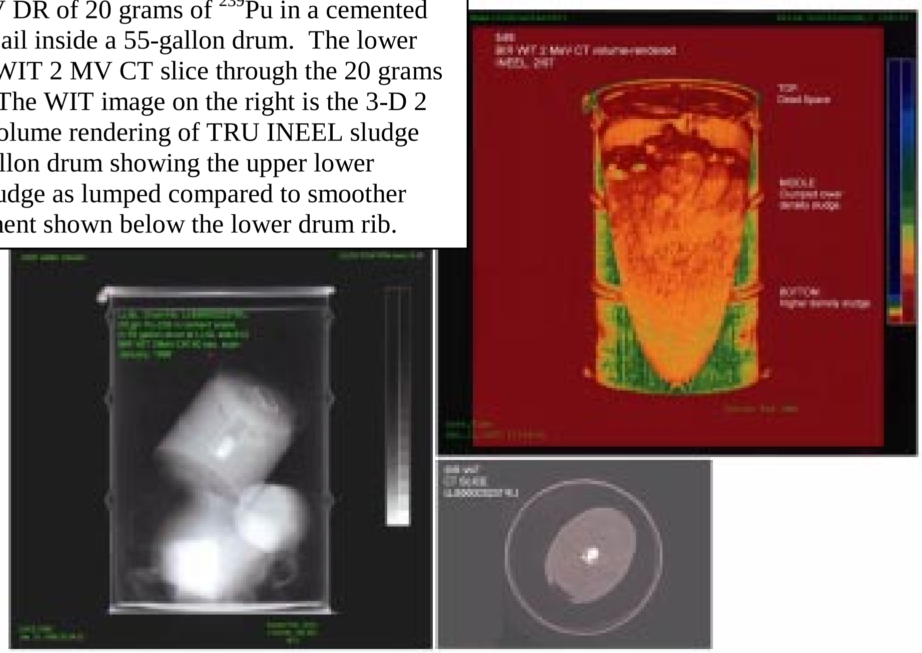

Figure 2. depicts WIT NDE capability on matrices that are typically difficult for conventional real-time-radiography (RTR) which is considered the base-line NDE technology. These matrices include cement and sludge. Typically materials buried in either are not seen using the base-line technique of RTR. From the above WIT NDE images, it is apparent that WIT has the ability to see into dense matrices as well as lightweight matrices to identify drum content. Even an empty bottle is apparent in the DR image (left image) at the lower right (faint hollow oval) while at the same time Pu is evident in cement. Cement is also distinguishable from sludge, which is typically not possible with RTR. Typically WIT acquires 3 DR images (0 & 90 degrees plus a tilted image for free liquid determination) and 90 CT slices each 10mm thick per drum. Typical spatial resolution for DR and CT is one mm. One WIT DR image requires one minute and one CT slice requires eight seconds for data acquisition.

Since WIT collects both NDE and NDA data all in digital format, WIT allows for optional media storage. All video and computer monitor screens can also be video taped on-board WIT. However, video taped information is analog with limited (8-bit or 256 gray level) dynamic range and only 5 years of shelf life. The WIT computerized NDE and NDA data can be stored on computer media. WIT computer media storage options include the hard drive, archived to magnetic (Digital AudioTape-DAT) tape, compact disc, or removable optical disc. The preferred WIT archiving media of choice is optical disc because of a shelf - life of nearly 40 years. Each removable optical disc has a capacity of 2.6 GB. WIT typically collects over 200MB of data per drum for both NDE and NDA. Therefore up to 10 drums of WIT NDE and NDA data can be stored on a single removable and optical disk. At a WIT NDE and NDA throughput of 2 drums per hour, one days worth of WIT NDE and NDA data can be archived in just minutes. Typical WIT NDE images have a dynamic range of 16-18 bits (greater than 256,000 gray levels). This wide dynamic range allows WIT to image low density poly bags (layers of confinement) in the same 2 MV DR or CT image as cement or sludge which is something not possible with the limited dynamic range of 450 kV RTR.

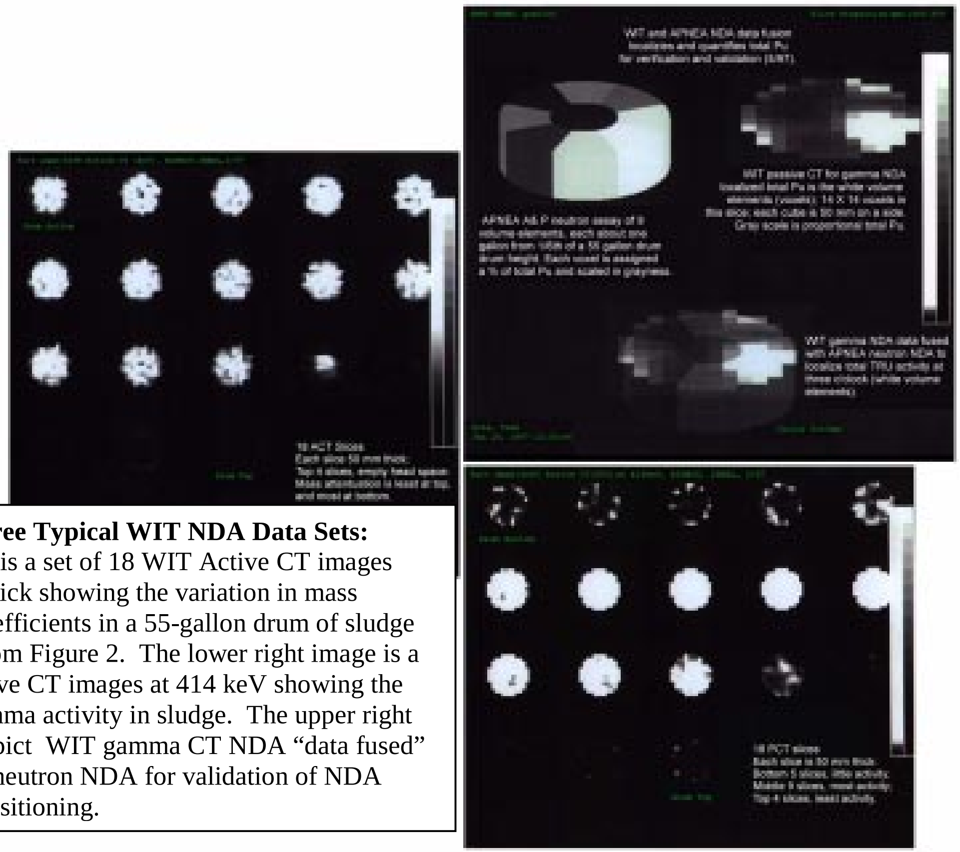

Figure 3. Three Typical WIT NDA Data Sets: The upper left is a set of 18 WIT Active CT images each 50 mm thick showing the variation in mass attenuation coefficients in a 55-gallon drum of sludge and cement from Figure 2. The lower right image is a set of 18 Passive CT images at 414 keV showing the "hot spot" gamma activity in sludge. The upper right hand slices depict WIT gamma CT NDA "data fused" with APNEA neutron NDA for validation of NDA using super-positioning.

Figure 3. is a look at WIT NDA capability. WIT has unique NDA ability in that it does not calibrate or rely on acceptable knowledge of waste drum matrix or radioactivity to perform gamma assay. WIT is an absolute measurement technique that determines the gamma spectra ratios and directly measures the activity present (e.g. ^{239}Pu) as an absolute measurement based on detector efficiency and measured matrix variations. Other techniques like Segmented Gamma Scanning (SGS) reply on apriori knowledge of the matrix, range of gram amounts or activity and isotopic makeup to perform an assay based on comparative calibration. Therefore accurate knowledge of the waste stream to be measured, accurate calibration standards, and accurate surrogate drum matrices are required to achieve correct NDA calibration for baseline techniques. WIT does not require calibration. WIT will take an unknown TRU drum of any matrix and provide an assayed value for total alpha activity and measurable gamma spectra without prior calibration. WIT needs efficiency, resolution, and collimated response function checks to verify readiness.

WIT NDE and NDA performance has been described by this author elsewhere (references 1 and 2). The WIT NDA techniques of Collimated Gamma Scanning (CGS) and Active and Passive CT (A&PCT) have been developed by LLNL and have also been described elsewhere (references 3 and 4). WIT currently has a minimum detectable concentration (MDC) of 220 nCi/gm and has measured between 0.1 and 104 grams of ^{239}Pu in individual TRU drums with matrices varying from zero (air) and combustibles through cement and sludge. WIT can collect a CGS spectroscopy data set within 30 minutes for a single drum. This data set is comparable to the conventional SGS NDA data set. The only major limitation thus far for WIT NDA capability, as been an A&PCT assay time of 1 drum per day. WIT has spent the past 3 years demonstrating its NDA A&PCT capability with one HPGe detector by participating in 3 DOE sponsored inter-comparison NDA tests demonstrating that A&PCT is an absolute measurement technique and capable of accurate and repeatable measurements of most waste streams. With this successfully accomplished in 1997, BIR has now (in 1998) been DOE funded for an upgrade to WIT which is to be completed early in 1999. The upgrade is designed to use 6 HPGe detectors in place on one detector to speed up WIT NDA assay time from one day per drum to less than one hour per drum for commercial utility. Figure 4. depicts the major element in the upgrade of WIT NDA, which is designed to speed up WIT assay time by more than a factor of 20. The current WIT design uses a translate-rotate geometry with intermittent stops for data collection. The upgraded geometry with 6 detectors will allow for continuous spiral (simultaneous elevation and rotation) motion of the drum to achieve a WIT assay time of nearly 30 minutes per drum. This geometry is also designed to allow for a reduction in the MDC to 100nCi /gm of waste to achieve measurements at the LL/TRU threshold. See reference 5. for WIT upgrade information.

Figure 4. The WIT NDA Upgrade with Multiple HPGe Detectors

THE HISTORY OF WIT

The concept for the CT of nuclear waste drums and WIT began in the early 1990's through this author's DOE SBIR grant with BIR . Two EM-50 contracts with BIR involving cost sharing allowed for the development and field testing of WIT at three DOE sites using PRDA (Program Research and Development Announcement) funding vehicles. BIR has been a leading international supplier of industrial CT technology since 1985. Thus BIR had developed CT NDE capability applicable to WIT prior to DOE WIT funding in 1990. BIR contracted with LLNL to transfer A&PCT NDA technology to WIT in 1993. WIT trailer development took place between 1990 and 1995 from concept to a full-scale production unit. Field-testing took place between 1995 and 1996 at 3 DOE sites and one commercial site. Inter-comparison testing for 3 different DOE test programs took place in 1997 with regulator oversight and verification of performance. DOE QA audits, the NDA upgrade, and the first commercial operation of WIT for the DOE took place during 1998. Table I. summarizes WIT's path to commercialization and its contracts with DOE.

Table I. WIT Contract History for Commercial Development with DOE

Dates	Contract/DOE Site	Work Description
1990-92	SBIR/HQ	The Feasibility of 2 MV CT NDE of Nuclear Waste Drums
1993-99	PRDA/EM-50, FETC	The Development and Field Testing of WIT NDE/NDA plus the WIT Upgrade for 6 detector A&PCT NDA
1993-99	WFO/LLNL	Technology Transfer of A&PCT NDA to WIT/BIR under a Work-For-Others Agreement
1996	BIR/B&W Lynchburg	First Non-DOE WIT Commercial NDE Contract
1996-98	PRDA/EM-50, FETC	The Integration of WIT and APNEA NDA
1996-98	RCI/FETC	A Rapid Commercialization Initiative for WIT NDE/NDA
1997	CEP/EM-50, INEEL	The Capability Evaluation Program for WIT NDA Testing
1997-98	PDP/CAO	The Performance Demonstration Program for WIT NDA
1998	TRUtech/CAO	Mobile Vendor QA Approval Program for WIT NDE/ NDA
1998-99	TRUtech/NTS	1st WIT NDE/NDA Commercial Service Contract for DOE

THE WIT ADVANTAGE

Computed Tomography (CT) revolutionized medical diagnostic radiology in the 1970s and 1980s by eliminating a large percentage of exploratory surgeries through depth and mass attenuation defining slice plane x-ray imaging of the human body. This ultimately saved medical insurance companies money, which over the years increased medical CT acceptance. The WIT CT analogy for nuclear waste drums is similar in that WIT 2 MV CT allows one to see into light and dense waste drums in 3-D to determine content and the need for repackaging. Fewer drums with indeterminate x-ray (RTR) findings and fewer remotely (glove box) repackaged nuclear waste drums will save DOE money. WIT has demonstrated its ability to see into dense drums that can now not be easily viewed with RTR. Dense waste drums that are difficult for RTR make up nearly half of the existing DOE TRU drum inventory currently located in interim storage. Today's total DOE TRU drum interim storage inventory is over 600,000 drums. Additionally, the Rapid Commercialization Initiative (RCI) (see reference 6.) has determined that WIT CT is comparable in cost per drum for NDE and NDA when compared with conventional RTR and SGS baseline techniques and has a cost advantage over the construction of new fixed characterization facilities. The advantages or benefits of WIT over baseline methods (e.g. RTR and SGS) are summarized in table II. below. It is basically these features of WIT that have prompted DOE to invest over $7M for the continued development and testing of WIT since 1990. In addition to complying with the WIPP Waste Acceptance Criteria (WAC) for TRU waste, WIT provides the following advantages over competing technologies:

Table II. The Features (Advantages) of WIT Compared to Baseline Capabilities

WIT Feature	WIT Benefit	Baseline Comparison
Mobile Trailer with "Approved" procedures and Field Experience	Temporary Facility w/ Trained Staff Has Categorical NEPA Exclusion & DOE/CAO Approved Procedures	Costlier New Fixed Facilities Needs 2 years DOE & NEPA study & approved procedures & staff
NDE & NDA Combined In One Trailer Facility	Less Drum Handling, Better ALARA with Only One Trailer Facility	Two New Facilities for both (NDE/NDA) Inspection methods
2 MV x-ray DR/CT NDE with 18-bit Detectors	Sees **All** Light & Dense Contents in one image (e.g. poly bags and sludge)	<450 kV RTR (8-12 bits) Images Light (**Half** of the) Drum Matrices
3-D CT Slices Eliminates Super-Positioning	Depth imaging, Counts Poly Bags with Density & Dimension Measures	RTR is 2-D Planar, Qualitative, has Overlapping Structures at all Times
Absolute NDA with Direct Measurement	Does Not Require Assay Calibration or Acceptable Knowledge (AK)	SGS Requires AK and Calibration with Surrogates, & is Comparative
A&PCT NDA of Hetero- & Homogeneous Matrices	3-D NDA of All Matrices-Attenuation Corrected Voxels for Mass/ Geometry	Limited to Light Homogeneous Matrices &Vertical SGS Segments
Data Fusion of NDE & Gamma/Neutron NDA	Multi-Modality Super-Positioning Validates Characterization Modes	Independent NDE/NDA does not Allow for Validation of Findings

INTERCOMPARISON TESTING AND REGULATOR VERIFICATION OF WIT

Tables III. and IV. summarize the quantitative NDA test results from WIT throughout 1997. These tests where conducted for the DOE by other contractors and tested WIT's ability to measure total alpha activity in TRU waste drums. These tests used the acceptance criteria for bias and precision for the measurement of total alpha activity in waste drums as defined by the National Transuranic Program from DOE. These tests were administrated and reviewed respectively by DOE and its regulators. (See reference 6.)

The three test programs at INEEL that WIT participated in throughout 1997 were the:

- PDP- Performance Demonstration Program (NDA for WIPP/CAO)
- CEP- Capability Evaluation Program (NDA for WIPP/EM-50)
- RCI- Rapid Commercialization Initiative (NDE and NDA for FETC)

Table III. WIT RCI PROGRAM BIAS & PRECISION RESULTS FOR WIT A&PCT GAMMA ASSAY from FEBRUARY 1997 at INEEL

TEST SAMPLE ID	WASTE IDENTIFICATION CODE	WIT % RSD (a) P = PASS F = FAIL	PRECISION QUALITY ASSURANCE OBJECTIVE (% RSD) (b)	TOTAL MEASURED ALPHA CURIES (GRAMS Pu-239)	WIT % RECOVERY (c) %R = x/μ P = PASS F = FAIL	% RECOVERY ACCEPTANCE CRITERIA (d) 95% CONFIDENCE BOUNDS LOWER %	% RECOVERY ACCEPTANCE CRITERIA (c) 95% CONFIDENCE BOUNDS UPPER %
1RF	300 (GRAPHITE)	7.0 (P)	< 7.0	2.6 (30.0)	127.0 (P)	57.4	142.6
2RF	336 (MOIST COMBUSTIBLE)	2.73 (P)	< 18.0	BELOW DL	BELOW DL (P)	43.5	171.5
1SG	440 (GLASS)	3.89 (P)	< 14.0	0.27 (3.1)	141.4 (P)	32.2	197.8
3RF	442 (RASCHIG RINGS)	2.95 (P)	< 14.0	1.2 (13.6)	122.3 (P)	33.1	196.9
2SG	330 (DRY COMBUSTIBLE)	4.15 (P)	< 14.0	0.13 (1.4)	162.5 (P)	32.5	197.5
4RF	376 (FILTERS/ INSULATION)	1.54 (P)	< 7.0	6.1 (69.4)	86.2 (P)	51.6	148.4
3SG	480 (METALS)	4.15 (P)	< 14.0	0.11 (1.3)	179.6 (P)	33.5	196.5
5RF(e)	001 (INORGANIC SLUDGE)	2.73 (P)	< 7.0	1.9 (21.1)	NON-EXISTENT RADIATION CHEMISTRY (UNKNOWN)	—	—

a: % RSD obtained from NDA PDP and CEP project replicate data sets, see footnotes 1 & 2.
b: Precision QAOs derived from National TRU Program NDA PDP performance criteria
c: %R based on single measurement (% recovery, x/μ measured value/known value)
d: Taken from NTP Performance Demonstration Program (PDP) bias scoring technique
e: Unable to evaluate performance due to lack of known drum radioactive material loading

DL = Detectable Limit; SG = Surrogate; RF = real waste originating from Rocky Flats
NOTE: The mean assay time was 22 hours per drum.

FOOTNOTES:
1. The WIPP QAPP requires assay precision based on six PDP replicate measurements.
2. The Capability Evaluation Program (CEP) was conducted in October of 1997 at the RWMC at INEEL using a test plan similar to the RCI evaluation plan. The CEP provided sufficient time for WIT to acquire precision data. The project referee identified a subset of drums tested under the CEP with similar physical and radiological content compared to the RCI drums. Under guidance from the RCI team, then project referee incorporated the precision statistics from the CEP and PDP replicate measurements into the RCI verification results.

Table IV. WIT NDA TEST RESULTS FOR BIAS & PRECISION USING WIT A&PCT GAMMA ASSAY FOR THE CEP & PDP PROGRAMS AT INEEL 8-9/97

TRU DRUM	1	2	3	4a	4b	5	6
DRUM ID#	CEPRF-20	CEPSG-6	CEPSG-9	CEPRF-11(a)	CEPRF-11(b)	PDP-003	PDP-001
CONTENT CODE	480	409	442	003	003	CYCLE 4	CYCLE 4
MATRIX	LEACHED METALS	MSE SALTS	RASCHIG RINGS	ORGANIC SLUDGE	ORGANIC SLUDGE	COMBUSTIBLES	ZERO
NET WEIGHT (kg)	109	68	64	140	140	44	0.5
REPLICATE #	8	8	8	7	7	6	6
MEAN MEASURED Pu-239 GRAMS	4.81	47.62	1.41	2.48	2.48	6.77	91.10
% RECOVERY	96.8	70.7	154.9	161.4	190.9	109.8	99.1
ALLOWABLE % RECOVERY RANGE	30.7-199.3	50.9-149.1	33.5-196.5	34.9-195.0	35.9-194.1	33-197	77-123
PRECISION % RSD	0.8	1.1	4.2	5.0	5.9	2.7	1.5
MAX. ALLOWED PRECISION % RSD	14	7	14	14	14	12	3.5
% TOTAL UNCERTAINTY	5.1	5.2	6.7	13.7	13.7	5.7	5.2
BIAS TEST	PASSED	PASSED	PASSED	PASSED	PASSED	PASSED	PASSED
PRECISION TEST	PASSED	PASSED	PASSED	PASSED	PASSED	PASSED	PASSED

a: Evaluation based on INEEL TWCP SAS assay system b: Evaluation based on radiochemistry of sludge samples
NOTE: Each replicate took less than 24 hours.

A MEMBER OF THE TRUtech TEAM

BIR INC.

WITCO

Waste Inspection Technology Co.

The RCI involved a number of regulators related to the DOE national TRU program who participated in the review and verification of WIT performance. Table V. is a list of the RCI team members consisting of those Federal and State organizations that participated in the WIT RCI program. (see reference 6.)

Table V. WIT RCI Team Members and Regulators

• The United States Department of Energy (OST/EM-50, FETC, and the Idaho Operations Offices)
• Lockheed Martin Idaho Technologies Company (Office of Program Execution)
• The United States Environmental Protection Agency (National Exposure Research Laboratory)
• The United States Army Corps of Engineers (Engineering Division, Walla Walla District)
• The Western Governors Association
• The Southern States Energy Board
• The State of California Environmental Protection Agency (Department of Toxic Substances Control)
• The Colorado Department of Public Health and Environment (Laboratory and Radiation Services Division)
• The State of Idaho, Air and Hazardous Waste Division (Hazardous Waste Permitting Bureau)
• South Carolina Department of Health and Environmental Control (Bureau of Land and Waste Management)
• The State of Washington (Department of Energy)

CONCLUSION

The road to WIT commercialization has been a path lined with existing entrenched (baseline) NDE and NDA technologies and government/regulator oversight with many years of history operating within the DOE complex. The introduction of the new innovative WIT technologies has involved WIT performance reviews and verification from a number of U.S. regulators including the DOE. The intent of the WIT technology holder (WITCO/BIR) to involve these regulators in the WIT review process comes from a plan to achieve WIT commercialization for DOE within the timetable associated with the opening of WIPP. Synergy between credible WIT evaluators involved in WIPP oversight and the TRU waste generator whose mission is driven by effective and affordable environmental remediation through waste drum characterization can aid in the successful commercialization of WIT. The successful WIT development, evaluation of efficacy, and DOE investment over the past eight years is evidence that WIT has demonstrated performance and cost benefits compared with the older baseline techniques of NDE RTR and NDA SGS. The future of WIT is dependent on the upcoming successful introduction of the WIT NDA upgrade and the continued acceptance of the cost-effective and improved WIT NDE and NDA technologies. Better technology like WIT is being accepted as its benefits and capabilities continue to demonstrate adherence to DOE's mission of more effective and affordable environmental remediation through improved TRU waste drum characterization. The future plans for WIT can be found in table VI.

Table VI. The Future of WIT in 1999 and Beyond

• Successful completion of the WIT NDA upgrade in spring of 1999
• Deploy WIT services at other DOE sites after NTS during 1999
• Secure capital financing for WIT production with increased DOE market share
• Build other WIT systems followed by DOE deployment
• Support multiple WIT deployments per WIPP management plans
• Pursue similar markets in foreign countries for WIT Technology Licensing
• Build strategic partnerships in the U.S. and abroad

- WIT development has been mostly funded by DOE FETC from Morgantown, WV, through an EM-50 PRDA contract: DE-AC21-93MC30173 along with partial support from the DOE Mixed Waste Focus Area. The DOE COR and the RCI program manager from FETC is P. Steven Cooke. The FETC contract administrator is Mary Spatafore Gabriel. The WIT program has also been cost shared by BIR. WIT CT NDE had been developed by BIR prior to DOE support for the project. All DOE contracts with BIR have been competitively bid by BIR.

- The WIT CGS/A&PCT NDA technology from LLNL has been transferred to WITCO/BIR through a work-for-others (WFO) agreement with LLNL PIs G. Patrick Roberson and Harry Martz, Ph.D.

- The CEP, RCI, and PDP programs where administered and refereed by DOE contractors respectively through Michael McIlwain of LMITCO at INEEL, Gregory Becker of LMITCO at INEEL, and Charles Macinkiewicz of CONTECH from Maryland.

- WITCO/BIR employees involved in the development of WIT have included Kenneth Hill for mechanical design, David Entwistle for software and program engineering, David Nisius, Ph.D. for germanium detector support and gamma spectroscopy, consulting nuclear physicist David Camp, Ph.D., and Richard Bernardi, the WIT Program Manager and Principal Investigator.

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