Proceedings of the 2nd Annual Tank Integrity Workshop

November 13-15, 2001

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Executive Summary

On November 13-15, 2001, 25 people attended the 2nd Tank Integrity Workshop in Las Vegas, NV. Attending were representatives of the major Department of Energy (DOE) high-level waste tank sites, Hanford, Savannah River, Oak Ridge, and Idaho along with representatives of the Defense Nuclear Facilities Safety Board (DNFSB), the DOE Office of Environmental Health (DOE-EH), the DOE Office of River Protection, the Tanks Focus Area (TFA), and the Characterization, Monitoring, and Sensor Technologies Crosscutting Program (CMST). The meeting was organized for the TFA Safety Program by the Iowa State University Center for Nondestructive Evaluation (CNDE).

The application of nondestructive evaluation techniques to validate the integrity of DOE high-level waste tanks was the subject of intense discussion. Attendees were able to learn from the experiences of their colleagues at other sites, gain valuable insights from the DNFSB representatives, and prioritize future activities in this area. Particular attention was directed to:

***Integrating the electrochemical noise corrosion probe into tank operations**

As an action item, a TFA representative and a site user volunteered to lay out a path towards the implementation of this monitoring device in the baseline tank integrity program at a DOE site.

***Leak integrity vs. Structural integrity**

There appeared, to many attendees, an insufficient technical basis to the regulations governing the continued use of tanks after leaks have been discovered. For example, a tank that is structurally sound, but has very small leaks, could conceivably continue to be used with a liquid level above the leak sites if the leaks are very small and can be managed by the site. Such tank usage could be important at sites with low waste storage volume but is precluded by current regulations. The DNFSB does not wish to engage in attempting to justify use of leaking tanks through probabilistic risk assessment. The Board spoke on the use of leaking tanks in Rec 2001-1 HLW Management at SRS. The operator of the leaking tank should explore all possible alternatives to its use including evaporation and better waste management. See **http://www.dnfsb.gov/pub_docs/dnfsb/rec_2001_01_sr.pdf**

***Vapor phase and water line corrosion**

Meeting attendees noted that additional research is needed to understand the mechanisms of vapor phase and water line corrosion, which are held to be important phenomena. A multi-site team, working together with TFA, agreed to organize a meeting of corrosion subject matter experts in January 2002 to discuss strategies for closing this knowledge gap. DNFSB staff expressed interest in attending the workshop.

***DOE headquarters interest in tank structural integrity problems**

Paul Wu, from DOE-EH, represented DOE-EM headquarters staff at the Las Vegas workshop and assured attendees that EM accorded tank integrity issues a high priority. He agreed to report on the workshop to his management and to help identify a DOE headquarters "champion" to help the program maintain its high visibility in Washington DC.

The workshop appeared to serve a need within the tank integrity community and received high marks from attendees.

Introduction

The production of nuclear weapons in the United States to help defeat the Axis Powers in World War II and to maintain national security during the Cold War required the construction of a vast nuclear facility complex in the 1940's and 1950's. These facilities housed nuclear reactors needed for the production of plutonium and chemical plants required to separate the plutonium from fission products and to convert plutonium compounds to pure plutonium metal needed for weapons. The chemical separation processes created "high-level waste" that was eventually stored in metal tanks at each site. These wastes and other nuclear wastes still reside at sites throughout the United States. At the Savannah River Site, a facility (the Defense Waste Processing Facility) has been constructed to vitrify stored high-level waste that will be transferred to the national high-level waste repository. The liquid wastes at the Idaho National Engineering and Environmental Laboratory have largely been stabilized as a mixture of oxide particles (calcines) but liquid wastes remain to be treated and the calcined waste will probably require further processing into a final, stable form. The Hanford Site is now in the initial stages of waste treatment facility design and has a large number of single-shell tanks, many of which are known to be leaking into the subsurface. The Oak Ridge Site, which did not produce "high-level waste" as defined by DOE, continues to rely upon tank storage for nuclear wastes although most of its older liquid wastes have been successfully stabilized. The site at West Valley, near Buffalo, NY, marks the location of the nation's only commercial fuel reprocessing facility. As a result of an agreement with the state of New York, the DOE assumed a major role in the stabilization of the high-level waste stored at this site and its eventual closure.

A feature common to many of these sites is that they must continue to rely upon large underground tanks to store dangerously radioactive wastes and, in many cases, these tanks are at or have already exceeded their design lives. The DOE Tanks Focus Area (TFA) was created in 1996 to help develop new technologies to, in part, measure the integrity of these tanks so that their continued safe use could be assured.

In 2001, technical staff members from Oak Ridge, Savannah River, West Valley Demonstration Project, Idaho National Engineering and Environmental Laboratory, Hanford, and the Defense Nuclear Facilities Safety Board met with TFA and CMST staff at a workshop organized by the CNDE for TFA to identify significant impediments, if any, to the safe operation and management of large storage tanks at their sites. A second goal of the meeting was to establish groundwork for collaborative efforts aimed at eliminating these impediments and the improvement of networking among individuals at the various sites. The attendees found the workshop useful and a second workshop was scheduled for FY2002.

Electronic copies of workshop presentations are included on this CD and hyperlinked to this text. Hard copies of the presentations are included in the bound copy of the proceedings. These presentations should be referred to for further details on the material presented below.

Workshop Organization and Description

Planning for the 2nd Tank Integrity Workshop (the "Workshop") was formally initiated during a June 28, 2001 conference call when the conference call attendees were asked to help select the date and location for the Workshop. Since the FY2001 workshop was held on the East Coast (Atlanta) it was felt that a West Coast location would be best for the Workshop. A majority voted to hold the Workshop in Las Vegas, NV from November 12 – 14, 2001, and space was obtained at the La Quinta Inns and Suites Northwest Tech Center for the meeting. The Workshop was advertised via e-mail to a large number of potentially interested participants. A brochure describing the Workshop is enclosed herein (see "**Meeting flyer.doc**"or Attachment A).

A planning group [Glenn Bastiaans (representing CMST), Martin Edelson (workshop planner for CNDE), Dan Pond (representing TFA), Dave Rehbein (NDE scientist at the Ames Laboratory), Mike Terry (representing TFA), and Bruce Thompson (CNDE Director)] met via conference call on September 17th to discuss the Workshop.

A consensus emerged that the Workshop be "outcome oriented" and focus on improving the site baseline Tank Integrity programs through communication between the sites so that "lessons" could be learned and through the discussion of improved technologies. A valuable "outcome" for CNDE would be an improved understanding of existing communications channels between the sites, feedback from the sites on useful mechanisms for providing technical assistance, and input from the sites on their technical priorities.

The best outcome from this meeting for DOE tank sites would be a detailed plan, with milestones and deliverables, for a set of actions that would assist them in their mission to ensure tank structural integrity. Based on last year's meeting, the sites have some energy for revisions in the DOE Order 435.1 implementation guidance. If the sites clarified their intentions in this area, a positive outcome from this meeting would be the establishment of a multi-site working group who could make a persuasive case for changes in DOE Order 435.1 the sites see as important.

The final Workshop agenda (see "**Agenda.doc**" or Attachment B) includes a mixture of site presentations, to help inter-site communications, presentations on NDE advancements to help communicate new technologies in NDE, and facilitated breakout sessions to isolate activities for future action.

Summary and Analysis of Workshop Discussions

Twenty-five people representing several DOE sites, DOE field and national management, DOE laboratories, the DNFSB, and universities attended the Workshop (see "**Attendees.doc**" or Attachment C)

Tuesday, November 13, 2001
The Workshop began the evening November 13 with a poster session and brief introductory talks by Paul Wu (DOE-EH), Mike Terry (TFA), and Ray Daniels (DNFSB).

Paul Wu (DOE-EH) introduced himself to the meeting participants and noted that he had been asked to represent DOE-EM staff at Headquarters who could not attend the Workshop due to a conflict with another meeting. He emphasized that there was strong recognition that tank integrity issues were critical to DOE site performance and his presence at the meeting could be taken as an indication of interest in TFA's Tank Safety program.

Mike Terry (TFA) discussed the progress that had been made in the Tank Safety program subsequent to the FY2001 workshop, activities within the TFA over the same period, and outstanding issues remaining from the FY2001 workshop. His presentation slides are provided at "M Terry.PPT" (see Attachment D). He can be reached at mike.terry@pnl.gov. Ray Daniels and Bill Yeniscavich work for the Defense Nuclear Facilities Safety Board. By their presence at the Workshop they underscore the DNFSB's concern about tank integrity issues and the interest for the TFA Tank Safety program.

Poster Presentations (see Attachment E)
"Remotely Operated Nondestructive Examination (RONDE) System," Contacts are Al Pardini, PNNL (allan.pardini@pnl.gov); Gary Duncan, CH2MHill (Gary_P_Duncan@rl.gov).

"Small Roving Annulus Vehicle Inspection Device," Contacts are Jim Wong, SRTC (jim.wong@srs.gov) and Al Pardini, PNNL (allan.pardini@pnl.gov).

"INEEL Tank Farm Issues," Contact is Ron Mizia, INEEL (rma@inel.gov).

"Savannah River Site Corrosion and Chemistry Probe," by John Mickalonis, Eugene Tshishiku, and David Hobbs, SRS.

"Materials Properties Database of ASTM A285," Author unspecified.

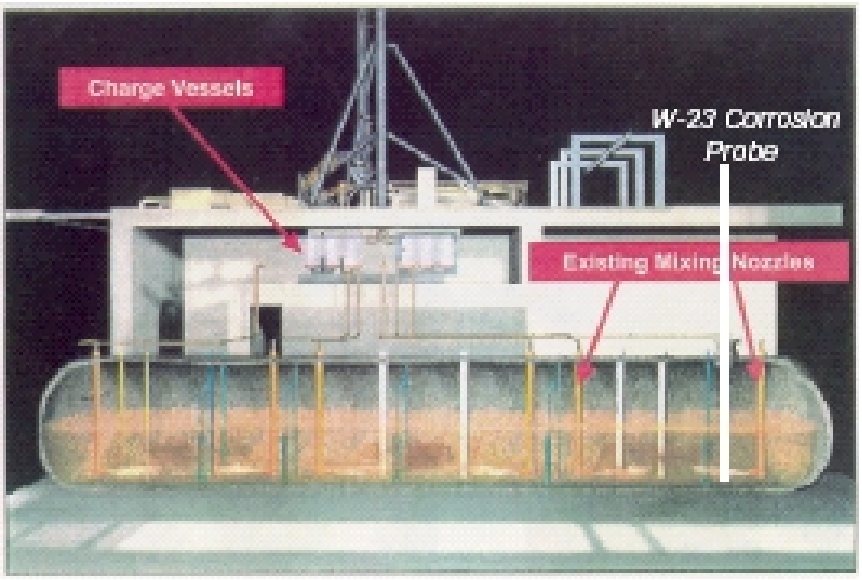
"Leak Mitigation of SRS HLW Tanks," Author unspecified.

"Demonstration of EMAT Potential as Inspections Screening Tool to Assure Tank Integrity: Hanford Site, September 2001," Contact is David Rehbein, Ames Lab (rehbein@ameslab.gov).

Wednesday, November 14, 2001
The morning of Wednesday, November 14, 2001 was devoted to the presentation of updates from DOE tank waste states and from the CNDE.

Oak Ridge site presentation (see Attachment F)
Brian Oakley briefed the Workshop participants in the progress made at Oak Ridge (see Oak Ridge Overview.pdf) since the FY2001 Tank Integrity Workshop under TTP OR00WT21, "ORNL Safety." Two deployments were conducted for ORNL Waste Operations facilities, a corrosion monitoring system was installed in W-23, a Bethel Valley Evaporator Services Tank, and a remote inspection system was installed at the Melton Valley Storage Tanks.

Tank W-23 is a 50,000 gallon, 304L stainless steel waste tank containing high concentrations of nitrates and nitrites at high pH. Corrosion processes of interest include uniform corrosion and stress corrosion cracking and pitting.

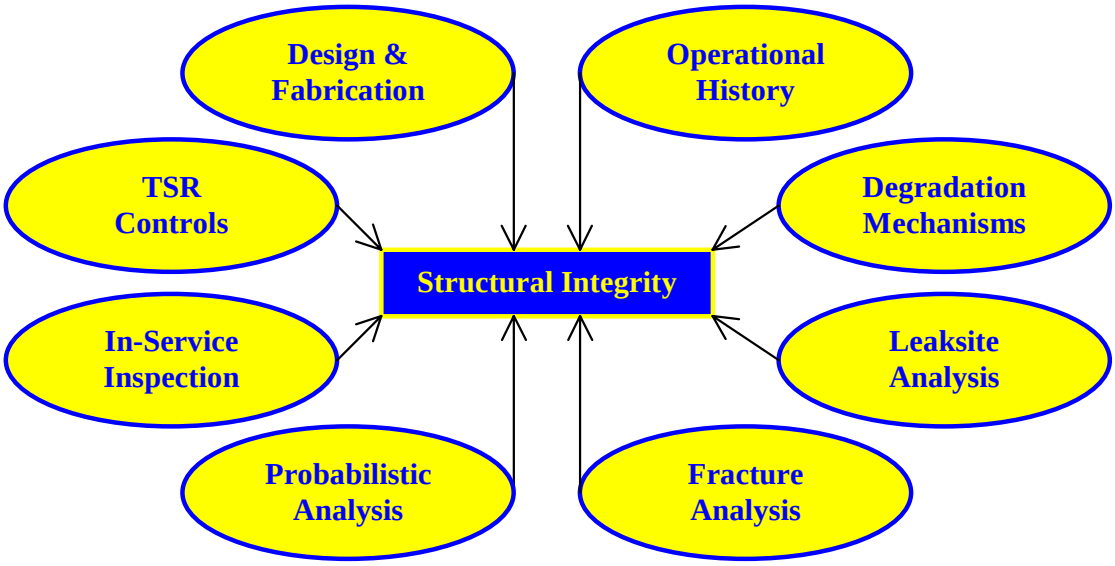


HiLine Engineering generated baseline electrochemical noise (EN) data for 304L stainless steel in surrogate ORNL waste and installed an EN corrosion probe in Tank W-23 in June 2001. Uniform corrosion and pitting corrosion were noted in the tests with surrogates but no stress corrosion cracking was recorded.

Data from the first five weeks on in-tank measurements have been analyzed and preliminary results published in, "ORNL Tank W-23 EN-Based Corrosion Monitoring: Comparison of Lab and Field Data Through First Month of Operation," by G.L Edgemon. They show that the probe is behaving as expected, that low rates of uniform corrosion are observed with occasional transients consistent with minor pit initiation. No gross surface damage or pit growth transients have been observed.

During FY02 additional data will be collected and analyzed and the probe will be eventually retrieved so that the electrodes can be inspected for corrosion damage.

Savannah River site presentation (see Attachment F)
Bruce Wiersma presented an overview of SRS Tank Structural Integrity Program Activities (see SRS Overview.ppt). The SRS program has many different aspects that were discussed by Wiersma. These are represented in the diagram below:



Fifty-one tanks constructed using varying techniques with different materials are present at SRS. Type I, II, III, and IIIA tanks are double-shell construction with annular regions that facilitate structural integrity investigations. There are eight Type IV tanks, which are single shell tanks that have been in service from 37 to 42 years. The Type I and II tanks were not stress-relieved and are therefore more susceptible to stress corrosion cracking than the Type III and IIIA tanks.

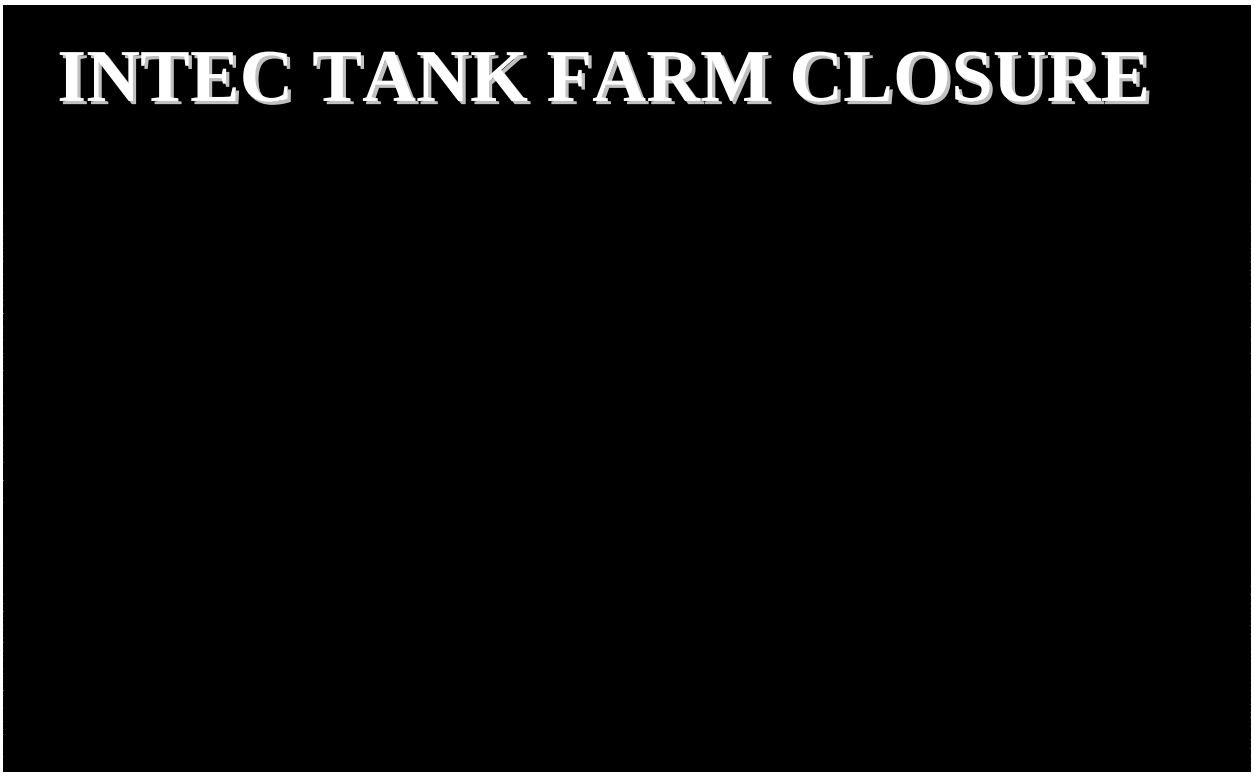
Wiersma reported on recent studies of degradation mechanisms related to a “crack-like indication” observed in Tank 15. The crack was unusual because it curved away from the weld, appeared when the waste level was well below the site of the anomaly, and was longer than previously observed cracks. SRS plans additional studies of this flaw.

Problems associated with Tanks 5 and 6 were discussed. These tanks had been used to successfully store small amounts of waste over the past twenty years but, after low activity waste was added this year, developed leaks. Questions arose about whether these leaks signaled a tank integrity problem and Wiersma described the application of a probabilistic risk analysis developed by LLNL to this problem. He also mentioned actions towards developing a method for applying material to the tank walls to cover the leak site and thereby mitigating the leak.

The presentation closed with a discussion of future structural integrity activities at SRS including the installation of an electrochemical noise/Raman probe into a SRS tank.

Idaho National Engineering and Environmental Laboratory site presentation (see Attachment F)
Ron Mizia presented the overview of INEEL tank integrity issues (see INEEL HLW.ppt). INEEL currently stores two types liquid wastes in 11 300,000 gallon stainless steel tanks. First

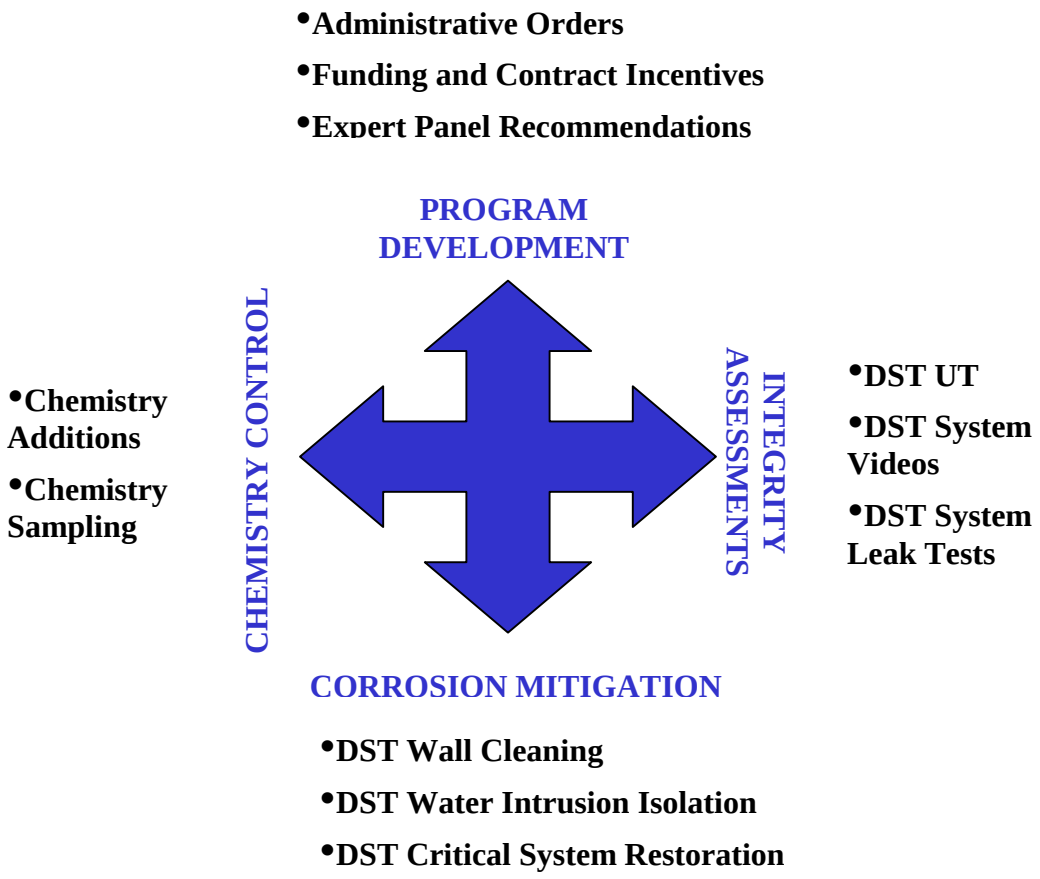
there is the waste that resulted from fuel reprocessing. INEEL also stores ~960,000 gallons of sodium-bearing waste that resulted from decontamination operations.



Corrosion rates have traditionally been determined from in-tank coupons. Through 1988, low rates of general corrosion (5.3×10^{-2} mils/year maximum) were observed with no evidence for localized corrosion. However, recent inspections have shown pit initiation in WM-183 and WM-187.

Due to questions surrounding the eventual disposition of the sodium-bearing waste, it is conceivable that the INEEL tanks may stretch the service time for these tanks considerably. INEEL is reviewing a Structural Integrity Program draft and developing functional and design requirements for remote NDE techniques. An electrochemical noise probe will be installed at INEEL in the near future.

Hanford site presentation (see Attachment F)
Gary Duncan presented an overview of the Hanford River Protection Project Double-Shell Tank Integrity Program (see Hanford Overview.ppt). The Double-Shell Tank (DST) Integrity Program at Hanford can be represented schematically, as shown below:



There are 28 1.1 million gallon DSTs at Hanford that currently hold 21 million gallons of waste. While conservative design and construction practices were followed in constructing the DST corrosion chemistry limits have not generally been followed (e.g., AN-102/107 have been out of specification for 17 years). Additionally annulus ventilation systems have not been maintained in many tanks. Stress corrosion cracking is a threat and there is a need to assure structural integrity but many important tank regions (e.g., the lower knuckle region) are difficult to access and some walls with severe corrosion cannot be inspected.

Duncan discussed DST integrity assessments that have been completed to-date, expert panel recommendations for additional activities, and additional technology improvements. In addition, progress to-date in DST chemistry control and corrosion mitigation along with expert panel recommendations were also reviewed.

The presentation concluded that current success in tank integrity understanding has been based upon the following the integrity program and that continued success depends upon continued management attention and future funding.

Center for Nondestructive Evaluation presentations (see Attachment F)
Bruce Thompson offered two presentations. The first was designed to introduce four technology presentations made by CNDE scientists that will be briefly discussed below. The second presentation dealt with a new FY02 task for CNDE, the determination of NDE methods for the study of the structural integrity of concrete (see CNDE Overview), which is an important factor for single-shell tank integrity. Candidate methods include:

- Visual
- Ultrasonic pulse velocity
- Rebound Number
- Acoustic Emission
- Electrochemical Testing
- Radiography Testing

Thompson proposed a workshop to bring together subject matter experts to determine the current state-of-the-art and to propose recommendations to advance NDE applications to measurements of concrete integrity relevant to single-shell tank safety.

Electromagnetic Acoustic Transducers (EMATs) and Guided Waves as a Screening Tool for Inspection (see EMAT tutorial.ppt)
Dave Rehbein provided a tutorial on the application of EMATs to tank integrity measurements. An EMAT uses a combination of electrical and magnetic fields to create an acoustic wave inside of an electrically conducting medium. Since the wave is inside the material being tested it is relatively insensitive to surface conditions, such as corrosion, and the method interrogates a large volume relatively quickly. EMATs can detect various obstructions to wave propagation such as pits and cracks. They can also determine thin spots in a plate via monitoring phase velocity.

Rehbein discussed some results obtained during a demonstration of EMATs at the Hanford site in September 2001 jointly organized by an EMAT vendor (SonicSensors) and the Ames Laboratory (Rehbein). These results are elaborated upon in a poster presented by Rehbein (see EMAT demo at RL.ppt) at the Workshop.

TSAFT Analysis (see Roberts-TSAFT Analysis.pdf)
Ron Roberts (CNDE) discussed work he has conducted in collaboration with Pardini and Diaz at PNNL. The PNNL group has developed an NDE method, called T-SAFT (Tandem-Synthetic Aperture Focusing Technique), to interrogate curved sections of tanks, such as the knuckle region. T-SAFT measurements generate very complex signals that are difficult to analyze and Roberts presented a discussion of his approach to understanding T-SAFT signals from basic physical principles.

Tank Integrity and Magnetic Measurements: The Evaluation of Material Condition from Magnetic-Property Measurements (see Magnetic measurements.ppt)
Marcus Johnson (CNDE) presented information about the application of magnetic methods to the NDE determination of steel microstructure. First, Johnson mentioned that magnetic measurements were accompanied by hysteresis phenomena that readily can be parameterized. While NDE determinations of microstructure are not available, it seems possible to correlate

parameters from magnetic measurements with microstructure. This was demonstrated in FY01 on two steel samples provided to CNDE from SRS. These measurements support a SRS need to classify the type of steels used in their tanks, particularly their carbon contents, since this classification can help identify tanks particularly prone to corrosion.

Potential Application of Ultrasonic Correlation Techniques to Underground Storage Tank Integrity (see Wormley UST integrity.pdf)
Sam Wormley (CNDE) discussed the application of direct-sequence spread-spectrum measurement techniques to the *in situ* estimation of the modulus of elasticity of structural concrete used in single and double shell underground storage tanks. The modulus can then be used to make inferences of the integrity of some large concrete structures, such as the those used in DOE underground tanks.

Lunch at Tenaya Creek
Lunch was held in a private room at Tenaya Creek, located close to the conference hotel. During lunch, two facilitators—Wendy Cain (Oak Ridge Operations) and Todd Conklin (LANL)—polled Workshop attendees about issues of greatest importance to them so that breakout sessions assembled later in the afternoon could discuss them in detail.

Breakout Sessions
The meeting reconvened in two venues: a meeting room within the hotel and a gazebo right outside the original meeting room.

Notes from Breakout Sessions
Following are the summary notes provided by the facilitators from the flip-charts used during the breakout sessions. The numbered topics represent the issues that garnered the most interest from meeting participants. They were:

Integrating the electrochemical noise probe, now being implemented at many DOE tank sites, into regular tank operations at the sites. An ancillary question is how data from the EN probes can contribute to site decisions.

Leak integrity vs. structural integrity is an issue at some sites. Due to storage volume shortages, the sites are interested in whether tanks with small leaks can be used for waste storage if leak mitigation activities are put in place.

Acceptance criteria for NDE testing, the sensitivity of NDE methods, and the application of the Guidance are still somewhat uncertain.

Vapor phase and water line corrosion mechanisms are felt to be poorly understood but are likely responsible for a significant amount of tank corrosion.

1. Electro-chemical Noise Analysis – Integrating Corrosion Probe into Operations
    - SRS uses a defense-in-depth to provide more data.
    - Interested in real-time analysis for control
    - A corrosion probe in sludge may be more economical for data than sampling

- How can the probe enhance, replace, or add to sampling?
    i. Possibly replace chemistry controls to keep the tanks in specification (requirements for mixing and adding)
- Need ability to interpret data or have a decision logic for analysis
    i. Consider using a lead lab instead of HiLine contractor for logic
    ii. Right now the expertise resides with one person, which is risky
    iii. Artificial intelligence/expert systems (need more data for decisions to program).
- Need a robust coupon retrieval system with more data/sampling capability with EN

2. Leak Integrity vs. Structural Integrity
    - The ability to demonstrate structural integrity is sound.
    - Decisions for tank use with respect to leaks – what are the potential and actual consequences?
    - Is there a technical basis for decisions or just philosophical/perception-based decision?
    - Consider a systems perspective of risk.
    - Does probabilistic risk assessment have a role to play with leak integrity?
    - Do we know root cause? What are the mitigative actions taken? Can these add to the technical basis?
    - Manage the trade-off of limited resources and storage capacity – how to best use the resources we have?

3. Acceptance Criteria – Inspections, Flaw Disposition, and Sensitivity of Ultrasonic Thickness Testing
    - Criteria from TSIP guidance
    - What action is taken if a flaw exceeds the criteria? What is our strategy to address?
    - Acceptance criteria kick in reporting requirements and different actions at Hanford.
    - INEEL needs sensitivity to detect pit-sized flaws in stainless steel (right now the detection limit is too high).
    - Note that the UT acceptance criteria limits are different than the design requirements for the EMAT system, which is a screening tool.
    - DOE Order 435.1 (TSIP) guidance document needs more specificity to provide sites with information to act/implement. This will ensure that sites have a consistent response.
    - Can we plot year-to-year pitting data to show a progression of pitting and predict future pitting?
    - How can we integrate EN and UT data?

4. Vapor Phase and Water Line Corrosion
    - Better understand corrosion mechanisms and characteristics
        - ➢ Understand how pitting occurs

    - Understand stress corrosion cracking and propagation
- Stress relieving processes – There are differences between Hanford and SRS. What are the implications?
- Strategic issues for TFA FY 2003 funding needs to be prepared by the end of February 2002 (workshop to be held earlier to identify possibilities).

In addition to the four issues discussed above, the breakout session participants were concerned about the visibility that tank integrity issues had at DOE headquarters. Paul Wu was asked to discuss the workshop in Washington and help to identify a "champion" for the program.

The group agreed that quarterly conference calls were useful and that they could serve to help monitor progress made in addressing the issues identified above during the fiscal year. Mike Terry will identify overall progress and work with one point of contact on each action item.

The group discussed possible venues for the next Tank Integrity Workshop. Santa Fe was mentioned as a possible location. It was also suggested that the next workshop be planned for two full days.

Thursday, November 15, 2001
The original plan for the Workshop was to run until Noon on Thursday but, after September 11th, check in time at the airport had increased significantly and a large portion of the Workshop participants had to leave considerably before Noon.

Thus the meeting on Thursday was primarily devoted to planning a path forward from the deliberations to guide activities during FY2002.

Path forward from the Workshop

A series of "action items" were identified at the Workshop for concerted action during the coming year:

***Electrochemical noise probes**

Several sites are using electrochemical noise probes but there isn't a common understanding about how the results from probe measurements should contribute to decision making at the sites. It was decided that probe use should be studied and information distributed throughout the complex. Additionally, SRS agreed to post papers on the use of neural networks for electrochemical noise probe signal analysis on the TFA web site so that all sites have ready access to this information.

***Use of Probabilistic Risk Analysis to Qualify Tanks for Continued Use**

Many DOE sites are facing shortages of liquid storage volume to facilitate waste treatment. In some instances they are prohibited to use tanks that are structurally safe but have very minor leaks. It is believed by some that such tanks can be safely utilized without materially contributing to risks to human safety or environmental integrity. Staff who support the DNFSB discussed this subject with site representatives at the Workshop. They agreed to

inquire about the Board's receptiveness using probabilistic risk assessment to qualify such tanks for continued use at the sites.

***Guidance for DOE Order 435.1**

DOE Order 435.1 is not easily applied to tanks at some DOE sites. For example, the stainless steel tanks at INEEL are not directly addressed by the Order. The need to revise the Guidance for DOE Order 435.1 was discussed during the Workshop and a group agreed to meet after the Workshop to discuss how best to revise the Guidance so that it could be applied at all DOE tank sites.

***Waterline and Vapor-Phase Corrosion**

It has been observed that much of the tank corrosion noted at DOE facilities occurs either at the "waterline" or above the waterline. Corrosion at these locations is poorly understood but, apparently, is important. SRS agreed to coordinate a future workshop to bring corrosion subject matter experts together to discuss these phenomena and to identify methods to mitigate resulting damage. The DNSFB has taken an interest in this problem.

***Tabulate Available Ultrasonic (UT) Methods**

CNDE agreed to survey available ultrasonic methods for nondestructive evaluation and construct a table that includes important method details including sensitivity.

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"Materials Properties Database of ASTM A285,"
Author unspecified.

"Leak Mitigation of SRS HLW Tanks,"
Author unspecified.

"Demonstration of EMAT Potential as Inspections Screening Tool to Assure Tank Integrity: Hanford Site, September 2001,"
Contact is David Rehbein, Ames Lab (rehbein@ameslab.gov).

Attachment F: Site Presentations

Oak Ridge site presentation

Contact is Brian Oakley, Oak Ridge (oakleybd@ornl.gov)

Savannah River site presentation

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