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Safely Storing Tank Waste

Remotely Operated Nondestructive Evaluation (RONDE) System

Pacific Northwest National Laboratory (PNNL) developed an ultrasonic inspection technology that makes it easier to ensure that the radioactive waste tanks at the Hanford Site are able to safely store waste until treatment can be completed. The double-shell tanks that store millions of gallons of radioactive waste are aged and require close monitoring. The Remotely Operated Nondestructive Evaluation (RONDE) system uses ultrasonic waves to perform an in-depth inspection of the tanks’ knuckle regions, where the tank walls curve to meet the floor. The most vulnerable to stress corrosion cracking, the knuckle region was not entirely accessible using conventional technologies. The RONDE is currently the only ultrasonic imaging technology that can detect cracks on the lower knuckle where it intersects with the floor.

The RONDE uses sound waves from the more accessible region of the tank wall, just above the knuckle. The sound spreads around the knuckle and along the bottom of the tank, and the returning sound waves are processed using a signal processing technique known as Synthetic Aperture Focusing (SAFT). A PNNL-developed software then uses this information to process high-resolution images of the entire knuckle region. The images can be used to detect and locate stress corrosion cracks in the knuckle region.

PNNL developed a two-transducer technique for the RONDE to accurately measure the length and depth of a crack. The method, an advanced nondestructive evaluation method, Tandem-SAFT or T-SAFT, involves placing two transducers next to each other and moving them back and forth in a pitch-and-catch mode to characterize the crack based on loss of signal.

The RONDE qualified to perform inspections on the knuckle region of Hanford tanks after passing a performance demonstration test, which confirms that it can detect and size cracks that could be circumferentially oriented in the knuckle region of a primary tank.
Double-Shell Tank Thermal and Seismic Analysis

PNNL initiated a 3-year effort under CH2M HILL’s Double-Shell Tank (DST) Integrity Program to complete an analysis of record for the DST system. The thermal and seismic analytical tasks include assessment of thermal and operating loads, seismic analysis, liquid level increase, minimum tank wall thickness, and tank buckling. This project supports the integrity assessment for the DST system under Tri-Party Agreement Milestone M-48-14, and periodic dome loading considerations that frequently arise from day-to-day operations. During FY03, PNNL completed a finite element model of a representative DST, and initial thermal and operating load cases were analyzed to current codes.

This analysis included the soil elements well beyond the tank boundaries to more realistically represent the condition of the tank, something not done in previous analyses. A more accurate temperature distribution within the concrete and surrounding soil along with thermal cycling and concrete creep for 60 years was also included.

The initial results are generally consistent with previous analyses.

- The primary and secondary steel liners have adequate capacity to meet the demands.
- The reinforced concrete dome, haunch, wall, and base mat have adequate capacity to meet the demands.

Additional investigations and sensitivity analyses have been initiated to determine the adequacy of the footings. Additional analysis include a more careful evaluation of the soil modulus under the tank as well as other detailed calculations to demonstrate structural integrity.
Technical Support on Retrieval and Storage

PNNL conducted tests and provided technical support to resolve key vapor and gas issues around the retrieval and transfer of certain tank wastes.

- **Technical Support of Accelerated Retrieval for Areas of Vapor Release and Aerosol Generation Predictions and Testing.** PNNL and CH2M HILL used nonradioactive simulants and the C-200 vacuum retrieval system (VRS) to estimate the quantity of suspended materials in the C-200 series tanks. The tests were conducted at the Hanford Cold Test Facility. PNNL published the results of study in *C-200 Series Tanks Vacuum Retrieval System Aerosol Test Results*, PNNL-14408.

- **Documented Safety Analysis of Flammable Gas Issues.** PNNL provided scientific and engineering support for flammable gas issues for the Documented Safety Analysis (operations basis for the tank farms) to CH2M HILL under the FY03 PNNL Flammable Gas Project. This support included technical document publication and review as well as participation in control decision meetings.

- **Waste Mixing and Mobilization Assessments.** PNNL worked with CH2M HILL to assess and minimize costs associated with the waste mixing and mobilization needs at Hanford. For the W-211 Project, it was determined that only one mixer pump, not two as originally planned to be installed, would be needed for the DST AN-101. The assessment led to the elimination of one mixer pump, saving the project approximately $1 million.
Also, PNNL was part of CH2M HILL’s Slurry Transfer Expert Panel, which consisted of seven members from DOE national laboratories and industry. The panel reviewed the transfer pipeline system from the Hanford waste tanks to the vitrification plant and determined that the current system is adequate, and a new system is not needed.
Developing Supplemental Treatment Technologies

Low-activity waste in Hanford’s underground tanks may be suitable for immobilization using one or more technologies that supplement the borosilicate vitrification process to be used at the Waste Treatment Plant. These supplemental technologies could significantly accelerate low-activity waste immobilization at reduced costs.

Evaluating Supplemental Technologies

PNNL provided key support in evaluating the three supplemental technologies: steam reforming, bulk vitrification, and cementation or the cast stone process. Specifically,

- PNNL developed a balanced strategy to evaluate the relative performance of the waste forms from the three different supplemental treatment options. This strategy was published in *A Strategy to Assess Performance of Selected Low-Activity Waste Forms in an Integrated Disposal Facility* (PNNL-14362).

- PNNL studied the characteristics of the waste forms produced by steam reforming and bulk vitrification. In addition, PNNL completed waste form contaminant release calculations for all three supplemental technologies and the baseline Waste Treatment Plant glass. This information was used in a preliminary risk assessment to evaluate the impacts of the disposal facility on public health and environmental resources. The characterization studies were documented in *Laboratory Testing of Bulk Vitrified and Steam Reformed Low-Activity Waste Forms to Support a Preliminary Risk Assessment for an Integrated Disposal Facility* (PNNL-14414).

- PNNL developed a nonradioactive saltcake simulant recipe and prepared, characterized, and delivered equivalent batches of simulant to the supplemental treatment vendors to ensure a balanced evaluation of each option. In addition, PNNL prepared and delivered pretreated radioactive dissolved saltcake waste to the vendors to support validation of their waste simulant testing.

- PNNL helped develop strategies regarding hazard classification, nuclear safety, hazard analysis, and licensing strategy for supplemental technologies.
Technical Assistance on Bulk Vitrification

One of the three options considered for treating low-activity waste, bulk vitrification allows for radioactive and mixed waste to be converted into radioactive aluminosilicate glass inside a large steel box. The container can then be transported to a disposal site, with no need for further treatment or packaging. PNNL provided extensive technical assistance to CH2M HILL’s bulk vitrification vendor AMEC Earth and Environmental Inc. Specifically,

- PNNL conducted laboratory-scale tests using crucible melts to develop a successful baseline glass formulation. Radioactive confirmation testing of the formula was also conducted. This formula is less sensitive to sulfate concentrations than the borosilicate glass formula, which could mean higher waste loadings than the baseline vitrification process.

- In the Radiochemical Processing Laboratory, PNNL supported radioactive engineering-scale tests to evaluate the bulk vitrification process and support a technetium material balance. The glass in the engineering-scale melts was made by combining soil, small amounts of chemical additives, and simulated tank waste in a container about the size of a desk. The mixture was then heated, vitrifying the simulated waste.

- PNNL evaluated the durability of waste forms created in lab-, engineering-, and full-scale tests. Samples from each waste form underwent toxicity characteristic leaching procedure, product consistency test, and vapor hydration test at the Applied Process Engineering Laboratory. In addition, phase identification tests were conducted using optical microscopy, scanning electron microscopy, and x-ray diffraction. This test provided data on the consistency of the melt, showing possible crystalline formations inside the glass structure.
Accelerating Tank Closure

Support Hanford’s Tank Closure Environmental Impact Statement

For the Environmental Impact Statement for Retrieval, Treatment, and Disposal of Tank Waste and Closure of Single-Shell Tanks at the Hanford Site (Tank EIS), PNNL provided key support in preparing data packages, which are starting points to develop analyses and assess alternatives for closing the 149 single-shell tanks and ancillary facilities. Within budget and on schedule,

- PNNL provided leadership and coordinated several data packages, including the packages on worker and public safety and supplemental treatment. This complicated task involved coordinating work with specialists, from small contractors and CH2M HILL.

- PNNL provided concepts and technical data for the closure data package, which consisted of five technical documents. This activity included providing details on placing tank farm barriers, the key environmental protection for the surrounding environment from the tanks today and from future tank leaks. PNNL also provided a design conceptualization of how monitoring systems could be placed in the barrier; these systems would monitor subsurface hydrology and geology as well as the movement of contaminants through the subsurface.

- PNNL helped develop information on gaseous and particulate emissions for five data packages associated with construction, operation, and decontamination and decommissioning activities.

- PNNL was the primary author for the safety data package.

- PNNL conceptualized alternatives for closing tank farms, such as the complete removal of the tanks, ancillary equipment, and all contaminated soil plumes. These alternatives have been discussed previously but never conceptualized.

- PNNL provided technical support in addressing comments from the DOE Office of River Protection, and their National Environmental Policy Act contractor, Science Applications International Corporation.
Water and Acid Leach Tests of Tank AY-102 Waste

PNNL characterized DST AY-102 sludge and drainable liquid to develop realistic source term release models for the long-term risk assessments required to close underground radioactive waste tanks. Archived samples from tank AY-102 were used as a surrogate for tank C-106. Material from tank C-106 was not available; therefore, archived samples from tank AY-102 were used because tank AY-102 contains waste pumped from tank C-106. The tests included physical characterization, quantitative analysis of waste composition, and water leach and acid digestion. The results showed that the average water leachability of technetium-99 is 20% over the 1-month time frame of the test. That is, technetium-99 is not completely water leachable as was previously assumed. The results show that future releases from tanks as a result of leaching by water will be very tank specific.

Additional tests were initiated on tank AY-102 waste to characterize the solid phases potentially limiting contaminant releases to water. Results will be reported in fiscal year 2004.

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