Tank Closure Progress at the Department of Energy's Idaho National Engineering Laboratory Tank Farm Facility

K.A. Lockie
U.S. Department of Energy
Idaho Operations Office
1955 Fremont Avenue
Idaho Falls, ID 83415, USA

L.C. Suttora
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585, USA

K.D. Quigley
CH2M◆WG Idaho, LLC
P.O. Box 1625
Idaho Falls, ID 83415, USA

N. Stanisich
Portage Environmental, Inc.
1075 S. Utah Avenue, Suite 200
Idaho Falls, ID 83402, USA

ABSTRACT

Significant progress has been made at the U.S. Department of Energy (DOE) Idaho National Laboratory (INL) to clean and close emptied radioactive liquid waste storage tanks at the Idaho Nuclear Technology and Engineering Center (INTEC) Tank Farm Facility (TFF). The TFF includes eleven 1,135.6-kL (300,000-gal) underground stainless steel storage tanks and four smaller, 113.5-kL (30,000-gal) stainless steel tanks, along with tank vaults, interconnecting piping, and ancillary equipment. The TFF tanks have historically been used to store a variety of radioactive liquid waste, including wastes associated with past spent nuclear fuel reprocessing. Although four of the large storage tanks remain in use for waste storage, the other seven 1,135.6-kL (300,000-gal) tanks and the four 113.5-kL (30,000-gal) tanks have been emptied of waste and cleaned in preparation of final closure. A water spray cleaning system was developed and deployed to clean internal tank surfaces and remove remaining tank wastes. The cleaning system was effective in removing all but a very small volume of solid residual waste particles. Recent issuance of an Amended Record of Decision (ROD) in accordance with the National Environmental Policy Act, and a Waste Determination complying with Section 3116 of the Ronald W. Reagan National Defense Authorization Act (NDAA) for Fiscal Year 2005, has allowed commencement of grouting activities on the cleaned tanks. In November 2006, three of the 113.5-kL (30,000-gal) tanks were filled with grout to provide long-term stability. It is currently planned that all seven cleaned 1,135.6-kL (300,000-gal) tanks, as well as the four 113.5-kL (30,000-gal) tanks and all associated tank vaults and interconnecting piping, will be stabilized with grout as early as 2008.

INTRODUCTION

Background

The INTEC TFF is located on the INL Site. The INL is an approximately 2,305-km^2 (890-mi^2) reservation owned by the United States government and located in southeastern Idaho. In 1953, the Idaho Chemical Processing Plant, now INTEC, was chartered to recover fissile uranium by reprocessing spent nuclear fuel (SNF). In 1992, the DOE officially discontinued reprocessing SNF at INTEC. This decision changed INTEC's mission to manage, store, and treat reprocessing wastes generated from past and current operations and activities. The INTEC facility is located approximately 29 km (18 mi) from the closest eastern boundary, approximately 23 km (14 mi) from the closest western boundary, approximately 16 km (10 mi) from the closest southern boundary, and approximately 29 km (18 mi) from the closest northern boundary.

The TFF, located within the northern portion of INTEC, comprises eleven 1,135.6-kL (300,000-gal) below grade stainless steel tanks in unlined concrete vaults of various construction, four inactive 113.5-kL (30,000-gal) stainless steel tanks, interconnecting waste transfer lines, and associated support instrumentation and valves.

The DOE is closing the TFF tanks in response to a January 1990 Notice of Noncompliance and subsequent Consent Order. The Idaho Department of Health and Welfare and U.S. Environmental Protection Agency (EPA) issued the Notice of Noncompliance to the DOE because the tanks in the TFF did not meet the secondary containment requirements as set forth by Idaho Administrative Procedures Act (IDAPA) 58.01.05.009 (40 Code of Federal Regulations [CFR] 265.193). The resulting 1992 Consent Order (and subsequent modifications) required the DOE to permanently cease use of the five 1,135.6-kL (300,000-gal) tanks that are contained in five pillar-and-panel vaults by June 30, 2003. The Consent Order also required the DOE to permanently cease use of the remaining 1,135.6-kL (300,000-gal) tanks by December 31, 2012, or bring the tanks into compliance with secondary containment requirements. The DOE decided to close the TFF tanks because radiation fields would make compliance with secondary containment requirements impractical, and because the DOE did not anticipate a need for such storage after 2012. (Compliance is impractical because the radiation fields in the tank vault would prevent practical entrance by personnel to add equipment or upgrades to the vaults to meet the secondary containment requirements.)

The DOE recently evaluated options for tank waste treatment and INTEC facility disposition. This evaluation is discussed in the *Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement* (EIS) [1]. DOE issued the *Record of Decision for the Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement* on December 19, 2005 (70 Federal Register [FR] 75165), in which DOE decided, among other things, to select steam reforming as a treatment technology for the remaining tank waste and pursue a phased decision-making process by issuing an amended ROD in 2006. The initial 2005 ROD stated that the 2006 Amended ROD would specifically address closure of the TFF in coordination with the Secretary of Energy's Determination pursuant to Section 3116 of the NDAA for Fiscal Year 2005[1].

[1] DOE was sued in 2002 regarding its authority to determine whether certain reprocessing wastes associated with reprocessing of spent nuclear fuel are high-level waste. The NDAA clarified this authority by including provisions allowing the Secretary of Energy, in consultation with the Nuclear Regulatory Commission, to determine that certain reprocessing wastes associated with reprocessing of spent nuclear fuel are not high-level waste provided certain criteria are met.

The TFF tank waste is a mixed waste (radioactive and hazardous), so the tanks are being closed in accordance with DOE requirements as a radioactive waste storage facility and with State of Idaho Hazardous Waste Management Act (HWMA) and Resource Conservation and Recovery Act (RCRA) requirements for closure of an interim status HWMA/RCRA tank system. (Some of the soils surrounding the TFF components have been contaminated by past spills and leaks from transfer piping. Decisions regarding the remediation of these contaminated soils are being made pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA].) These requirements include preparing several documents. The documents describe DOE’s actions to close tanks and meet closure objectives. The DOE requires closure plans, a performance assessment (PA), and a composite analysis (CA) to address radioactive constituents. To meet HWMA/RCRA requirements, closure plans and sampling and analysis plans (SAPs) addressing the hazardous waste constituents are required.

In general, the closure process includes removing the tank waste for treatment then closing the tanks to meet RCRA and Section 3116 NDAA criteria[2]. The TFF tank system’s closure process includes waste removal; cleaning of the tanks, piping, and ancillary equipment (to remove waste to the maximum extent practical); and removal of remaining liquid and solid waste residue to the maximum extent practical from the tanks and ancillary equipment. Following waste removal from the tanks and TFF cleaning activities, confirmatory sampling and analysis are performed to assess the decontamination effectiveness and for waste characterization.

Some residuals that cannot be removed by the cleaning process or other technically practical means will remain. The residuals will be sampled and analyzed to determine the concentrations of radioactive and hazardous constituents remaining in the tanks. As each TFF component is cleaned and analytical data show that performance objectives are expected to be met, the DOE plans to stabilize each of the applicable TFF components by filling them with grout. Process lines will be decontaminated and capped, and all lines (including process lines) that provide a pathway to the tanks will be grouted and capped. (A ROD under the CERCLA process to address capping of contaminated soils in the TFF is expected to be issued in 2007.)

Since the TFF remains operational to provide interim storage of approximately 900,000 gal of radioactive liquid waste awaiting final treatment, the first step for tank closures was to consolidate the tank waste into three of the newest 1,135.6-kL (300,000-gal) tanks. (In addition, one 1,135.6-kL [300,000-gal] tank remains operational as a spare tank.) This was accomplished in 2002.

Since that time, extensive efforts have taken place to clean and begin closure of several TFF components. Those efforts include cleaning of seven 1,135.6-kL (300,000-gal) tanks and the four 113.5-kL

[2] Section 3116(a) of the NDAA states, “In General—Notwithstanding the provisions of the Nuclear Waste Policy Act of 1982, the requirements of section 202 of the Energy Reorganization Act of 1974, and other laws that define classes of radioactive waste, with respect to material stored at a Department of Energy site at which activities are regulated by a covered State pursuant to approved closure plans or permits issued by the State, the term “high-level radioactive waste” does not include radioactive waste resulting from the reprocessing of spent nuclear fuel that the Secretary of Energy (in this section referred to as the “Secretary”), in consultation with the Nuclear Regulatory Commission (in this section referred to as the “Commission”), determines—(1) does not require permanent isolation in a deep geologic repository for spent fuel or high-level radioactive waste; (2) has had highly radioactive radionuclides removed to the maximum extent practical; and (3) (A) does not exceed concentration limits for Class C low-level waste as set out in Section 61.55 of title 10, Code of Federal Regulations, and will be disposed of— (i) in compliance with the performance objectives set out in subpart C of part 61 of title 10, Code of Federal Regulations; and (ii) pursuant to a State-approved closure plan or State-issued permit, authority for the approval or issuance of which is conferred on the State outside of this section; or (B) exceeds concentration limits for Class C low-level waste as set out in section 61.55 of title 10, Code of Federal Regulations, but will be disposed of— (i) in compliance with the performance objectives set out in subpart C of part 61 of title 10, Code of Federal Regulations, and (ii) pursuant to a State-approved closure plan or State-issued permit, authority for the approval or issuance of which is conferred on the State outside of this section; and (iii) pursuant to plans developed by the Secretary in consultation with the Commission.”

(30,000-gal) tanks, and their associated vaults, interconnecting piping, and ancillary equipment. Implementation of the NDAA legislation provides a framework for DOE to grout in place all of the TFF tanks once emptied and cleaned. Three of the four 113.5-kL (30,000-gal) TFF tanks were grouted in place in 2006 prior to the onset of adverse weather conditions. The work involved in accomplishing the TFF cleaning and grouting is described below.

Tank Farm Facility Description

Placed into service between 1953 and 1966, the eleven 1,135.6-kL (300,000-gal) tanks (WM-180 through WM-190) are approximately 15.2 m (50 ft) in diameter and 6.4–7.0 m (21–23 ft) in height. Nine of the eleven 1,135.6-kL (300,000-gal) tanks are constructed of Type 304L stainless steel; two tanks (WM-180 and WM-181) use Type 347 stainless steel. The 1,135.6-kL (300,000-gal) tanks are housed in concrete vaults, with the bottom of the tanks located approximately 13.7 m (45 ft) below grade level. The vaults have one of three different designs: (1) octagonal pillar-and-panel vaults (five tanks), (2) cast-in-place square vaults (four tanks), and (3) cast-in-place octagonal vaults (two tanks). Cooling coils on the floor and walls of eight of the tanks (WM-180, WM-182, WM-183, WM-185, and WM-187 through WM-190) provide heat transfer capabilities. The 15-cm (6-in.) thick concrete vault roofs are covered with approximately 3 m (10 ft) of soil to provide radiological protection to workers and the public.

Each tank has four or five 30-cm (12-in.) diameter risers to provide access to the tank. Tanks WM-184 through WM-190 also have one or two 46-cm (18-in.) diameter risers. Most risers have installed equipment and instrumentation, including radio frequency probes for level measurement, corrosion coupons, and steam jets and airlifts for waste transfer operations. Two steam jets are located inside each tank, except for Tanks WM-189 and WM-190, which have one steam jet and one airlift pump. High-pressure steam is forced through a steam jet to create a suction pumping action to remove liquid from the tank.

A single steam-jet pump can transfer waste out of a tank at approximately 50 gpm. The original design of the suction pumps restricts the ability of the pumps to clear the tanks of liquid completely. Using original steam jet placement and prior to any actual cleaning activities, an 8–30-cm (3–12-in.) deep residual containing both liquid and solids remains on the floor of the tanks. Therefore, steam-jet pumps are lowered to the bottom of the tank for final tank cleaning. Figure 1 presents the dimensions and structure of a typical 1,135.6-kL (300,000-gal) tank.

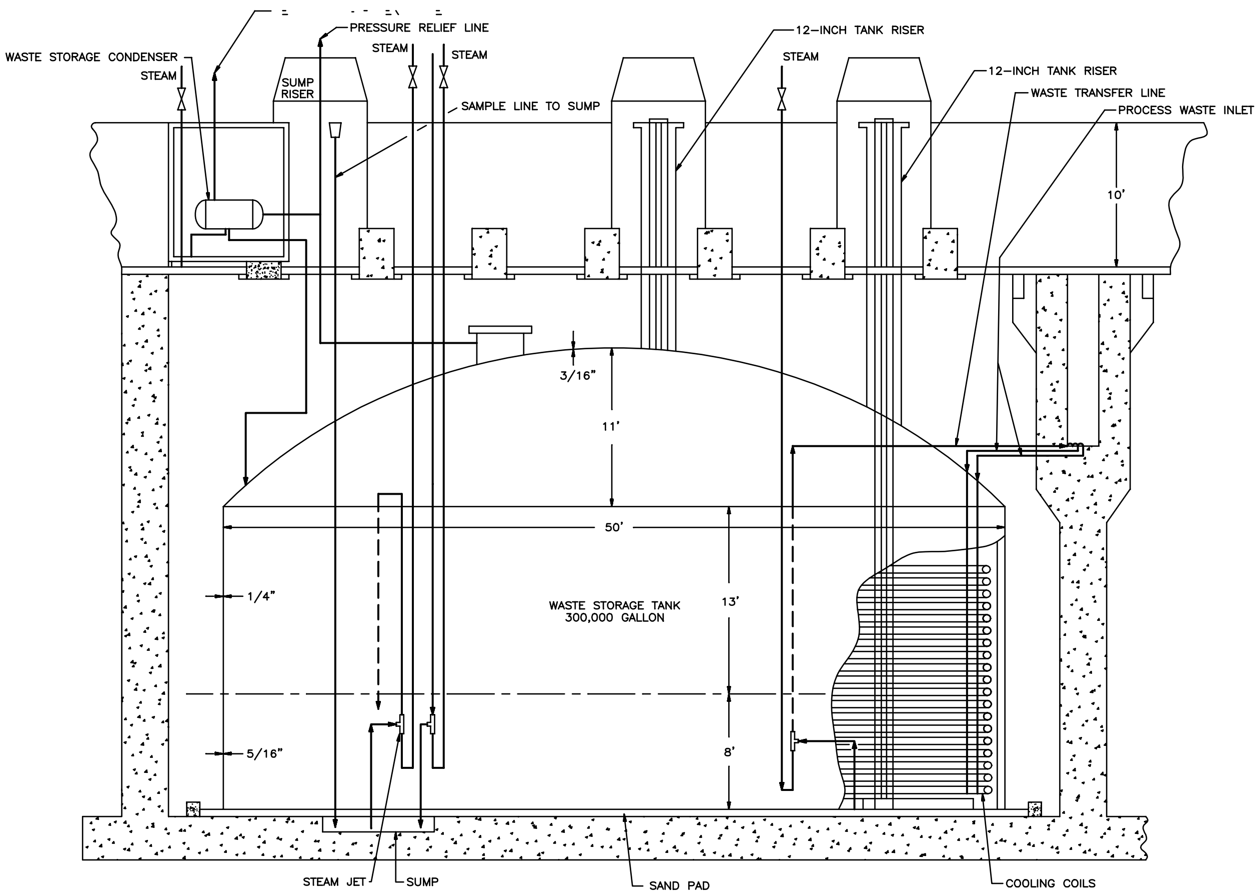

Fig. 1. Cross-sectional view of a typical tank with cooling coils.

When the TFF was constructed, the 1,135.6-kL (300,000-gal) tanks were designed with flat bottoms. The concrete floors of the tank vaults were designed with sloped floors to promote drainage of any liquid toward the perimeter of the vaults for efficient removal. In order for the tank to rest on the sloped floor without causing unacceptable stresses in the tank, a leveling pad of sand was installed to support the tanks. The sandpad is 15 cm (6 in.) thick at the perimeter and 5 cm (2 in.) thick at the center. The exterior of the sandpad extends 15 cm (6 in.) beyond the outer edge of the tanks and is confined by a curb measuring 15 by 15 cm (6 by 6 in.). The volume of the sandpad is 23.39 m^3.

Constructed in 1954, the four inactive 113.5-kL (30,000-gal) stainless steel below grade storage tanks (WM-103 through WM-106) sit on reinforced concrete pads. The tanks are horizontal cylinders approximately 3.5 m (11.5 ft) in diameter and 11.6 m (38 ft) in length. The 113.5-kL (30,000-gal) tanks do not have vaults. All four tanks contain stainless steel cooling coils to provide heat transfer capabilities. Three 15-cm (6-in.) diameter risers and one 8-cm (3-in.) diameter riser that reach to grade level provide tank access. Tank steam jets are provided for liquid waste removal (nominal flow rate of 50 gpm). These tanks were removed from service in February 1983.

Liquid waste transfers to, from, and among the tanks are managed through a system of lines, valves, and diversion boxes. Waste transfer lines are contained within one of the following types of secondary encasements: split tile, carbon steel, stainless steel-lined concrete troughs, double-walled stainless steel pipes, or buried directly in concrete. Because of upgrades over the years, the pipe sections encased within carbon steel and split tile have either been replaced or abandoned in place, except for two small (about 1.5-m [5-ft]) sections that are no longer used. The majority of the upgraded piping is contained in stainless steel-lined concrete trenches with the remainder in double-walled stainless steel piping. Double-walled stainless steel piping was used primarily in areas where single pipe runs were upgraded or where access did not allow lined trench installation. Liquid waste is routed through waste transfer valves located below grade, in stainless steel-lined concrete boxes (referred to as valve boxes). The waste transfer valves are operated manually using reach rods. The valve boxes are designed to provide access to the valves for inspection and maintenance.

Cleaning Approach for TFF Tanks and Vaults

A tank cleaning system comprising a washball, directional nozzle, and modified steam-jet pumping system has been developed and used successfully thus far in the TFF tank cleaning operations (see Figure 2). During washball and directional nozzle operations, the steam-jet ejectors (shown in Figure 1) are operated to remove the waste-containing slurry from the tank. The goal of tank cleaning is to remove as much waste as practical. During this operation, radiation levels are monitored on the steam-jet transport line as an indication of cleaning effectiveness. Monitoring the radiation levels near the transport line provides the cleaning system operators and project manager with an indication of when continued tank cleaning ceases to be effective. When radiation levels decrease to the lowest value and remain constant, cleaning is stopped and the tanks are inspected. If visual inspection via a remote-controlled camera confirms that the tank has been cleaned to the extent practical, then samples are collected and analyzed to verify performance objectives are met. During the visual inspection, residual solid waste depths are estimated by comparing the solids depths to benchmarks within the tanks such as cooling coil support brackets and associated welds. For example, in tanks with cooling coils, the bottom weld and stainless steel bracket thickness measures 0.97 cm (0.38 in.). Knowing this thickness, the depth of waste next to these brackets can be estimated. A reflection from the stainless steel at the tank bottom indicates that no solids are present The radiation monitor allows tank cleaning to proceed without repeated visual inspection or sample collection and aids in ensuring that as much waste as practical is removed from the tanks. Samples of the residuals are collected with small positive-displacement pumps. Submersible pumps are lowered into the bottom of tanks or vaults through risers. The pump is activated and liquid and solids are pumped to sample containers on the surface. The submersible pump can only reach the residuals directly beneath the riser through which it is lowered. However, because the residuals will be agitated before sampling, it is reasonable to assume that the liquid in the tank is homogeneous and the flocculent solids may be in suspension.

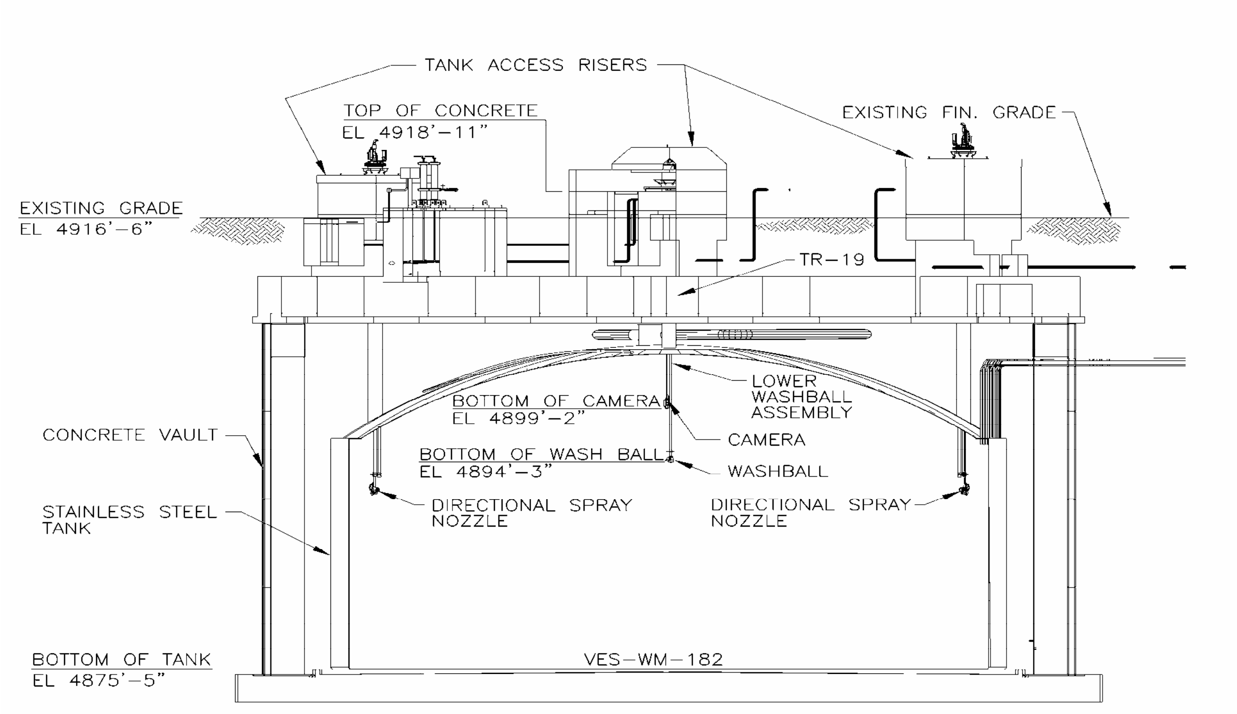

Fig. 2. Typical tank cleaning system.

Prior to its implementation, the TFF tank cleaning system was tested in a full-scale mockup tank using simulated waste [2]. The system demonstrated effectiveness in subsequent tank cleaning. The washball/directional nozzle tank cleaning system and the modified steam-jet pumping system were used to slurry the solid and liquid wastes and remove them from the tanks. Steam jets were modified by cutting the steam supply and discharge lines, and installing a new steam jet lower in the tank. During cleaning system development, the INL Site and the DOE Tanks Focus Area (TFA) performed a review of tank cleaning technologies. The DOE formed the TFA to address all aspects of remediating radioactive wastes from underground storage tanks DOE-wide, including tank cleaning technology. The TFA review is described in a report prepared by the Pacific Northwest National Laboratory [3]. This review focused not only on the technical feasibility and appropriateness of the approach selected by the INL Site but also on technology gaps that could be addressed by using technologies or performance data available at other DOE sites and in the private sector. The review supported the design and implementation of the INL Site cleaning system. As a result of this development and testing work, the cleaning system (washball, directional nozzle, and modified steam-jet pumping system) has performed better than expected.

The tank vaults are cleaned by iterative flushing with water. The water is removed using the existing steam jets. Access to the vaults is limited and initial radionuclide inventories are considerably less than the tanks; therefore, flushing is a practical and effective cleaning method. Process piping in the TFF is cleaned by triple flushing, which consists of flushing three piping system volumes through the system with a pressure equal to previous waste transfers to ensure that the pipe area contacted by waste has been contacted by water and rinsed during the flushing operations; this method has been shown to be effective based on analytical data. The acidic nature of the waste, and the procedures that required flushing with water after waste transfers during operations, limited accumulation of residuals in piping that needed to be removed.

The vaults provide secondary containment for tank leakage. The tanks have not leaked during the life of the TFF. The contamination in the vaults for Tanks WM-185 and WM-187 resulted from two back-siphoning events that occurred early in TFF operations. In all tank vaults, rainwater/snowmelt in-leakage through the vault roof has been pumped periodically from the vault sumps to waste tanks.

Tank residuals remaining after cleaning and before grouting consist of a relatively small amount of solids and contaminated flush water. Extensive mockup testing shows that most of the remaining flush water and some solids will be removed during the grouting process for stabilizing the residuals. This action will be accomplished by using the grout to push and corral the residuals toward the removal equipment (jet pumps). Any remaining residual liquid will be stabilized with a grout material.

Prior to grouting, the small amount of liquid waste in the vault sumps will be emptied using the existing steam-jet pumps. The lines connecting the vault sumps to the tanks will be grouted, followed by grouting of the vaults.

Results of Tank and Ancillary Equipment Cleaning from 2002 to 2005

The results of visual inspection and sampling and analysis performed after tank cleaning operations were completed provide evidence that the cleaning technology used for the 1,135.6-kL (300,000-gal) tanks, 113.5-kL (30,000-gal) tanks, and ancillary equipment effectively removes the majority of highly radioactive radionuclides from the tanks while keeping occupational exposure to radiation as low as reasonably achievable (ALARA).

For the seven 1,135.6-kL (300,000-gal) tanks that have been cleaned as of May 2005 (Tanks WM-180 through WM-186), the washball and directional nozzle tank cleaning system was used to wash the tank walls and ceiling. The high-pressure water from the washball and directional nozzle also agitated the tank heel to suspend the solids and facilitate heel removal. The washball and directional nozzle were lowered into the tank through one of the tank risers. The water from the washball and nozzles hit the tank walls, roof, and heel, and dislodged the bulk of the contamination on the walls and ceiling of the tank to allow subsequent removal using the steam jets. A camera and lighting system was used to monitor the decontamination and heel removal effectiveness. Existing tank equipment and new equipment used for waste removal and decontamination operations were left inside that tank after these operations were completed for permanent disposal when practical. However, the washball and directional nozzle were decontaminated when moved to a new tank. The four remaining 1,135.6-kL (300,000-gal) tanks (WM-187 through WM-190) will be cleaned using the same methods after the sodium-bearing waste is removed for future treatment.

Visual examination indicated that the water spray removed solids from the tank walls easily. After tank cleaning operations were completed, post-decontamination samples of the residuals were obtained from the tanks and ancillary equipment. Samples from Tanks WM-180 through WM-186 were collected. A minimum of five samples were collected from each tank. The remaining tank contents were agitated between sample collections to ensure random selection of the samples. Because few solids remained on the tank bottoms, only a few grams of solids from one tank (WM-183) were retrieved during the sampling activities. Attempts to sample solid material in other tanks failed because of a lack of solid material available to collect. After cleaning, the tank floors have only isolated areas of solid residuals. Figure 3 shows how effective the tank washing has been in Tank WM-186; cleaning of other tanks has shown similar results.

The four 113.5-kL (30,000-gal) tanks (WM-103 through WM-106) were flushed with water to remove any residual waste. A tank cleaning system was not used for these tanks because of the low radionuclide concentrations remaining after previous tank flushing. Post-decontamination samples (at least five from each tank) from Tanks WM-103 through WM-106 were also collected.

Sampling and analysis were performed in accordance with SAPs prepared in conjunction with the tank and ancillary equipment closure plans. Each SAP used the data quality objective (DQO) process to determine the sampling strategy, number of samples, and analytical methods to be used. Issues such as the representativeness of the samples obtained and the homogeneity of the population sampled are also addressed. The DQO process is a planning approach developed by the EPA for use in preparing sampling designs for data collection activities that support decision-making. The process is used to ensure that the type, quantity, and quality of data used in decision-making are appropriate for the intended application. The analytical results have been reported in a series of data quality assessment (DQA) reports, which are summarized in the Section 3116 Basis Document [4]. A DQA is a scientific and statistical evaluation of the quality of the collected characterization data to determine whether the data can be used to meet the DQOs that were established.

Fig. 3. TFF Tank WM-186 post-decontamination interior.

In this case, the results of post-decontamination sampling and analysis were used to determine the concentrations of the radioactive and hazardous constituents remaining in the tanks and ancillary equipment. Analysis results were used to confirm that the radionuclide concentrations met the closure requirements, and that they were bounded by the concentrations assumed in the conservative inventory in a 2003 PA [5]. The results were also used to estimate the residual TFF radionuclide inventories. Results of sampling and analysis of the residuals indicate that the radionuclide inventory in the tanks after cleaning is an order of magnitude lower than that estimated in the 2003 PA.

Residual Inventory in Tank Farm Facility Structures, Systems, and Components

Although the tank and ancillary equipment cleaning activities have been shown to be successful, some residuals remain in the TFF components after cleaning is complete. The residual inventory at closure is based on validated analytical data from tanks sampled between 2002 and 2005, after cleaning operations. This inventory describes the radionuclide concentrations in the TFF tank system residuals, assuming that the residuals in the four 1,135.6-kL (300,000-gal) tanks and ancillary equipment remaining to be cleaned have a radionuclide inventory similar to that of the residuals in the seven tanks and ancillary equipment that have already been cleaned. Radionuclide concentrations are decayed to 2012, the year of final TFF closure.

Tank volume estimates in the 1,135.6-kL (300,000-gal) tanks for solid residuals and interstitial water used in the residual inventory at closure are based on viewing videotapes of the tanks taken before, during, and after the final cleaning and sampling events. From the videotapes, residual solid depths were estimated by comparing the solids depths to the cooling coil support brackets and associated welds. Depth assumptions were based on the bottom weld and stainless steel bracket thickness measuring 0.97 cm (0.38 in.). Close-ups from the video were critical in determining the depths of residuals next to the brackets and areas where no apparent solid residuals were observed. Depths of solid residuals ranged from 0 to 0.97 cm (0 to 0.38 in.). Areas where no solids were present on the bottom of the tank were apparent by the reflection from the stainless steel bottom. The volume of solids and the density of the solid material were used to determine the mass of residuals in each tank. Videos and photographs of the tank walls show staining and discoloration, and no discernible buildup of residuals. Therefore, no source term for the tank walls was included in the tank inventory. Inventories in the seven 1,135.6-kL (300,000-gal) tanks cleaned to date range from 475 Ci in Tank WM-181 to 2,394 Ci in Tank WM-182, almost entirely (~95%) made up of Cs-137 and its daughter product Ba-137m.

The vaults surrounding the 1,135.6-kL (300,000-gal) tanks provide secondary containment for the tanks. Since these tanks have never developed leaks, the tank vaults do not normally contain a significant radioactive inventory. However, a back-siphon event in Tank WM-185 and a second back-siphon event in Tank WM-187 occurred early in the TFF history and contaminated these two tanks vaults. Although the waste was promptly transferred out of these vaults after the events, and recent samples from the vault sumps did not indicate any significant inventory of radionuclides, a conservative estimate of 3,850 Ci per tank vault has been made for PA models of a remaining source term in the vault sandpads that underlie these two tanks.

The residual inventory at closure for the 113.5-kL (30,000-gal) tanks is based on analytical data from post-cleaning sampling. Solid residual samples were not collected because an adequate volume of material was not present in the tanks. A film layer was observed on the lower half of all four tanks that appeared to be algae or another form of biological growth. This film layer was clearly not residual solids as found in the 1,135.6-kL (300,000-gal) tanks and is not likely to contain any significant radioactivity. However, to establish a conservative estimate, the film is assumed to be 5 mil (0.005 in.) thick and contains the concentrations of radionuclides found in Tank WM-183 solid samples. The inventories for each 113.5-kL (30,000-gal) tank vary from 36.2 to 36.7 Ci.

Residual inventories were also calculated for interconnecting process piping in the TFF. The residual inventory at closure for TFF piping is based on analytical results from sampling pipe sections that had been removed from the Tank WM-182 process waste lines after decontamination. The samples were obtained and analyzed as described in the associated SAP. From these results, the amount of residuals remaining in 3,231 linear m (10,600 linear ft) of process waste piping is calculated to be 15.5 kg of solid residuals in the piping. The radionuclide concentration from the tank residual inventory is then apportioned to the mass to estimate a conservative residual inventory of 30 Ci at closure for the piping.

To quantitatively address how effective the waste removal techniques have been, a mass balance approach was developed [4]. Historically, radionuclides were removed from the total TFF waste stream by removing the liquid waste for a calcination process. This inventory was identified by preparing a mass balance of radionuclides received from SNF reprocessing and sent to the TFF for storage and disposition. The mass balance relied on analytical data, numerical modeling, and data extrapolation to arrive at the total radioactivity present at INTEC from SNF reprocessing. The mass balance, which also considered nuclear material shipped to other DOE facilities for further processing, was used to determine the total radioactivity of waste generated from spent fuel reprocessing, which was 36 million Ci. Of the approximately 36 million Ci in 9.4 million gal of waste generated during spent fuel reprocessing operations, approximately 25,800 Ci are estimated to remain in the tank system following closure, representing about 0.07% of the initial spent fuel waste inventory.

ISSUANCE OF KEY AUTHORIZATION BASIS DOCUMENTS

A critical part of the progress in TFF cleaning and closure has been the development, review, and issuance of several key documents associated with tank closures, as identified below. Significant efforts have taken place over the last several years to provide the analyses and evaluations to support these key documents.

Section 3116 Determination

Section 3116(a) of the NDAA specifies that the term "high-level radioactive waste" does not include radioactive waste that results from reprocessing SNF if the Secretary of Energy determines, in consultation with the NRC, that the waste meets certain criteria. In 2005, a draft Section 3116 Determination for the INTEC TFF was developed and was submitted to the Nuclear Regulatory Commission (NRC) for review and consultation. The NRC concluded its review and consultation process [6] on October 20, 2006, and on November 19, 2006, the Secretary of Energy determined that the stabilized residuals in the TFF, and the TFF tank system, are not high-level waste and may be disposed of in place at the INL.

Amended National Environmental Policy Act Record of Decision

The DOE issued the *Idaho High Level Waste and Facilities Final Environmental Impact Statement* in October 2002 [1]. In issuing the *Record of Decision for the Idaho High Level Waste and Facilities Final Environmental Impact Statement* (70 FR 75165), DOE noted that an Amended ROD would be issued specifically addressing the closure of the TFF. On November 19, 2006, the DOE issued this Amended ROD to the *Idaho High Level Waste and Facilities Final Environmental Impact Statement*.

DOE Closure Plans

The Tier 1 closure plan is one of a suite of documents needed to demonstrate compliance with DOE requirements, as defined in DOE Order 435.1 and implemented through DOE Manual 435.1-1 and DOE Guide 435.1-1. This closure plan defines and bounds the parameters of the proposed closure approach to ensure the long-term protection of the public and the environment from a deactivated high-level waste facility closure. The Tier 1 closure plan was supported by two comprehensive evaluations, a PA [5] to evaluate the projected radiological dose impacts associated with the closure of the TFF, and a CA [7] to evaluate the potential dose impacts from other INL sources that may impact the closure of the TFF. The Tier 1 closure plan, issued on November 19, 2006, provides the basis for an authorization to proceed with grouting activities.

RCRA Closure Plans

The TFF closure is being performed under both DOE and State of Idaho requirements, which include preparing closure plans, since the wastes stored in the TFF are mixed wastes. As such, the State of Idaho regulates the hazardous constituents and the DOE regulates the radioactive constituents. In accordance with these requirements, the DOE has prepared a series of closure plans to support the TFF closure. These closure plans present the strategy for clean closure of the TFF tanks to site-specific action levels. The closure plan for TFF Tanks WM-187, WM-188, WM-189, and WM-190 will be submitted prior to closure. In addition, a final closure plan for all of the TFF tanks will be prepared and submitted to the State of Idaho for approval. Results of the confirmatory sampling and analysis of the TFF tank residuals for the TFF closure activities performed as of May 2005 indicate that HWMA/RCRA clean closure requirements as set forth in the closure plans have been met.

COMMENCEMENT OF TANK GROUTING

Grouting activities in support of final tank closure commenced on November 20, 2006, after the necessary authorizations discussed above had been received. Original planning for commencement of tank grouting assumed that the Section 3116 Determination, Amended ROD, and other relevant authorizations, would be received early in summer 2006. With this assumption, baseline schedules showed grouting to occur first in four of the 1,135.6-kL (300,000-gal) tanks, followed by grouting of the four smaller 113.5-kL (30,000-gal) tanks. Commencement of grouting in July 2006 would allow completion of these eight tanks by late in calendar year 2006. Grouting of the other three cleaned 1,135.6-kL (300,000-gal) tanks would occur in 2007, followed by grouting of all the interconnecting piping and ancillary equipment. Those activities were scheduled to complete during summer 2008. However, due to the late start of grouting activities and the difficulties of grouting during winter weather conditions in Idaho, plans were shifted to focus on grouting of the four 113.5-kL (30,000-gal) tanks, as these tanks required a much shorter duration of favorable weather. (Cold weather restricts grout batch plant operations and jeopardizes the ability to produce grout meeting minimum temperature requirements. Grouting of the 113.5-kL [30,000-gal] tanks was estimated to only require a few days of favorable weather, whereas the larger 1,135.6-kL [300,000-gal] tanks would require a several-week period of continuously favorable weather conditions.) As such, three of the four 113.5-kL (30,000-gal) tanks (WM-104, WM-105, and WM-106) were filled with grout during the week of November 20, 2006. Preparations were completed for grouting of the fourth tank by November 27, 2006; however, due to the onset of severely cold weather, grouting operations were suspended, with plans to resume grouting in spring 2007.

FUTURE GROUTING OF THE 1,135.6-kL (300,000-GAL) TANKS

Grouting plans for summer 2007 include completion of several of the large 1,135.6-kL (300,000-gal) tanks. The plan for grout addition in these large tanks is based upon significant mock-up engineering efforts, and should provide the opportunity for additional residual liquid and solids in the bottom of the tanks to be removed.

The initial grouting process for the 1,135.6-kL (300,000-gal) tanks is comprised of: (1) an engineered grout placement sequence to move remaining solids and liquid toward the steam jets, aid in the mixing of residuals with the grout, and provide a reducing environment; and (2) an encapsulation grout pour to stabilize residuals on the surface of the grout placements and level the engineered grout placements.

The engineered grout placement sequence to move remaining solids and liquid toward the removal pumps is estimated to use 85 m^3 of grout. The grout will be introduced through two available risers with specially designed grout masts. The first two placements go in directly below the available risers to a height of 0.9–1.2 m (3–4 ft). The purpose of the first two placements is to begin moving residuals toward the steam jet for removal and to provide troughs to direct placements 3 through 5 to the other areas of the tank. In the grout mockup, these placements were successful in moving solid and liquid surrogate materials. Placements 3 and 4 use the same riser access as placements 1 and 2, and displace the residuals between the tank wall and the steam jet. The purpose of placement 5 is to displace the residuals on the opposite side of the tank from the steam jet. These placements flow through the trough to sweep residuals toward the steam jet. Placement 5 may be replaced with two separate placements to allow better residual removal, but the purpose of the placement is the same. Figure 4 shows a schematic of the grout placement approach.

Based upon mockup results, some portion of remaining residuals is likely to be pushed to the steam jet and removed during grouting. As such, use of this grouting approach provides a good opportunity for additional waste removal from the tanks. Methods are being investigated to provide an indication of the amount of additional waste removal achieved. Once the engineered grout placements are completed, a final encapsulation grout pour will be used to: (1) ensure adequate immobilization of any remaining residuals on the surface of the grout placements and (2) level the engineered grout placements. Once the engineered grout placements and encapsulation grout pour is complete for a particular tank, the entire tank will be filled with grout to provide long-term stability of the tank structure.

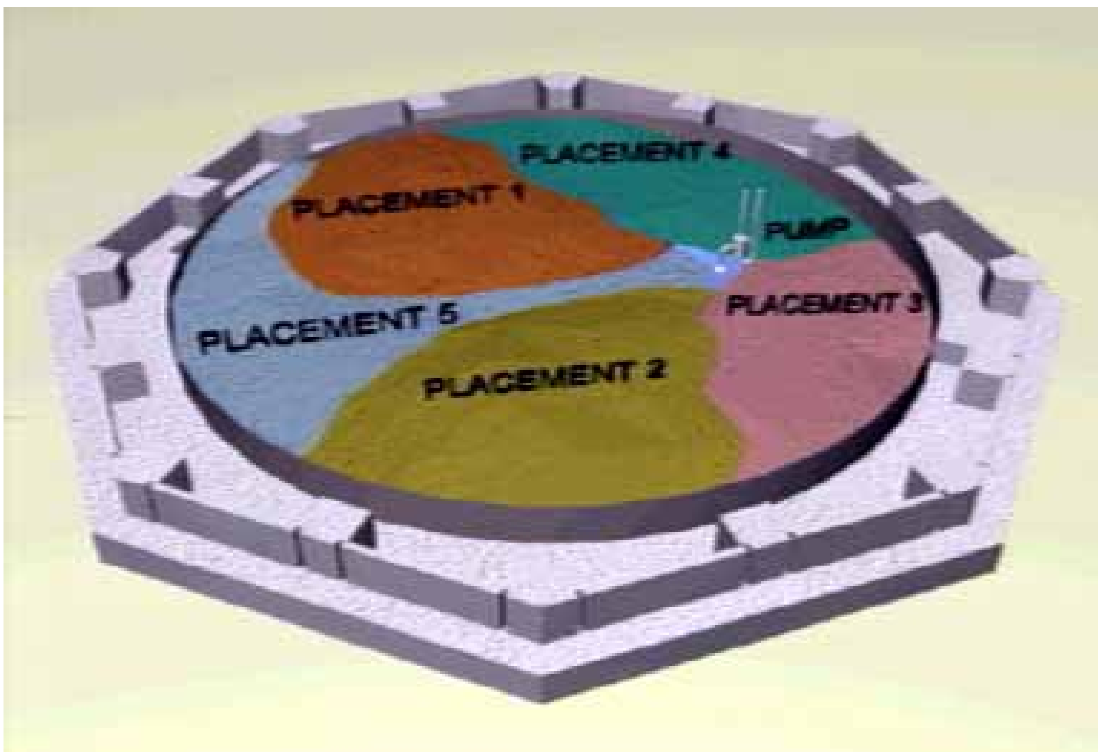

Fig. 4. Schematic of the engineered grout placement sequence.

SUMMARY

Significant progress has been made to clean and close emptied tanks at the INTEC TFF. Between 2002 and 2005, seven of the eleven 1,135.6-kL (300,000-gal) tanks and all four 113.5-kL (30,000-gal) tanks were cleaned and prepared for grouting to support final closure. Several key authorization basis documents, including a Section 3116 Determination and an Amended National Environmental Policy Act ROD, to support tank closures were issued by the DOE in November 2006. Also in November 2006, prior to a winter shutdown of grouting activities, three of the 113.5-kL (30,000-gal) tanks were filled with grout to provide long-term stability. It is currently planned that all seven cleaned 1,135.6-kL (300,000-gal) tanks, as well as the four 113.5-kL (30,000-gal) tanks and all associated tank vaults and interconnecting piping, will be stabilized with grout as early as 2008. The remaining four tanks in the TFF will be cleaned, sampled, and grouted by when they are no longer needed for waste storage. Closure of the TFF is planned to be complete by 2012.

REFERENCES

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