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Identification of Single-Shell Tank In-Tank Hardware Obstructions to Retrieval at Hanford Site Tank Farms

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IDENTIFICATION OF SINGLE-SHELL TANK IN-TANK HARDWARE OBSTRUCTIONS TO RETRIEVAL AT HANFORD TANK FARMS

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ABSTRACT

Two retrieval technologies, one of which uses robot-deployed end effectors, will be demonstrated on the first single-shell tank (SST) waste to be retrieved at the Hanford Site. A significant impediment to the success of this technology in completing the Hanford retrieval mission is the presence of unique tank contents called in-tank hardware (ITH). In-tank hardware includes installed and discarded equipment and various other materials introduced into the tank.

This paper identifies those items of ITH that will most influence retrieval operations in the arm-based demonstration project and in follow-on tank operations within the SST farms.

INTRODUCTION

High-level radioactive waste has been produced at the Hanford Site (located in southeastern Washington State) since 1944 as a byproduct of processing spent nuclear fuel for the recovery of plutonium, uranium, and neptunium. The first single-shell waste-storage tanks were completed and placed in operation in 1944. Between 1943 and 1964, 149 SSTs were built for the storage of radioactive wastes at the Hanford Site. These SSTs are located in 12 tank farms of 4 to 18 tanks each in the 200 West and 200 East Areas on the Hanford Site. No wastes have been added to the tanks since November 1980. Water, however, is added to one tank for evaporative cooling purposes. Pumpable interstitial liquid and supernatant wastes are removed from SSTs and transferred to double-shell tanks (DSTs).

Liquid waste accumulation and storage in the SSTs continued until 1980 when the DSTs were completed and used exclusively for receiving new waste. The 149 SSTs presently contain over 140 ML (37 Mgal) of waste.

The U.S. Department of Energy has established the Tank Waste Remediation System Program in the Office of Environmental Restoration and Waste Management to manage the waste in all 177 underground storage tanks at the Hanford Site for eventual disposal. Tank waste includes the contents of 149 SSTs, 28 DSTs (plus any new waste added to these facilities), and all cesium and strontium capsules currently stored onsite.

The waste retrieval program within the Tank Waste Remediation System will perform a series of retrieval demonstrations in both SSTs and DSTs to validate selected retrieval technologies. One of these projects, "Tank 241-C-106 Manipulator Retrieval System," will demonstrate a robot arm-based retrieval system and the supporting subsystems required to complete a retrieval demonstration milestone. Final retrieval of tank 241-C-106 waste must start by February 2002 and be completed by September 2003. The manipulator arm will then be deployed to other SSTs for use in other retrieval operations.

Types of In-tank Hardware

In addition to the typical sludge and hard saltcake, the SSTs contain other items that are incompatible with downstream waste-treatment processes. Categorized as in-tank hardware, these items can be further classified as 1) permanently installed, 2) riser-installed, and 3) miscellaneous/discarded.

Permanently installed ITH was often welded to the tank liner during tank construction. Another method of installing this type of ITH was to route it from outside the tank, through the tank wall, and then cement and/or weld it in place. Permanently installed ITH cannot be removed from the tanks intact because of its method of emplacement.

Riser-installed ITH is typically lowered down the vertical, pipe-lined penetrations of the tank dome (risers) and rigidly attached at the top of the riser, usually by a flange. Large portions of riser-mounted ITH, for example pump motors, can sit above the end of the risers and thus outside the tank interior. Also, riser-mounted hardware can be removed intact from the tanks, although this depends a great deal on the condition of each individual piece.

Finally, miscellaneous/discarded ITH encompasses an almost endless variety of items, from actual hardware to junk, that have been dropped into the tanks. These items were either discarded into the tanks through risers opened for that purpose or were originally riser-mounted ITH that was cut off and allowed to drop into the tank's interior. Some articles of miscellaneous/discarded ITH cannot be removed intact from the tanks because of their size and complexity.

In-tank Hardware Descriptions

Air Lift Circulators. Air lift circulators (ALCs) (Figures 1 and 2) were used to agitate tank wastes and prevent waste solids from settling. This was accomplished by injecting compressed air into the bottom of a 25.4- to 40.6-cm- (10- to 16-in.-) diameter pipe held off the bottom of the tank. The rising air would lift the waste entrapped in the ALC and circulate it to the upper layers of the tank waste. Older SSTs have riser-mounted ALCs while newer SSTs have ALCs that are welded to the tank bottom. Bottom-mounted ALCs are guyed with cables and are connected to ceiling-mounted, compressed-air lines.

Air lift circulators are widespread throughout the tank farms and they pose a considerable challenge to arm-based retrieval operations. Some ALCs have been encrusted with saltcake accretions called "lollipops" (Figure 2) that weigh up to 18.1 metric tons (20 tons)[1] and preclude removing riser-mounted ALCs by simple extraction. Also, there is a high probability that the ALCs contain large amounts of entrained waste that would be difficult to reach with the robot arm.

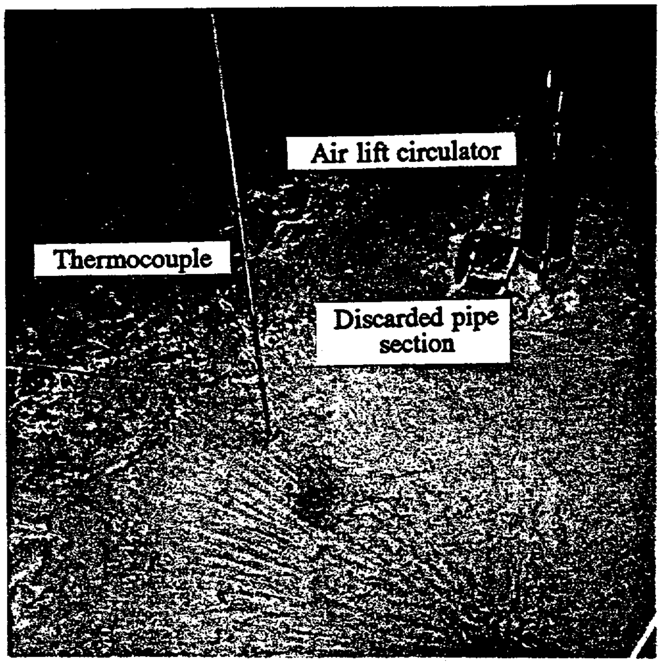

Figure 1.

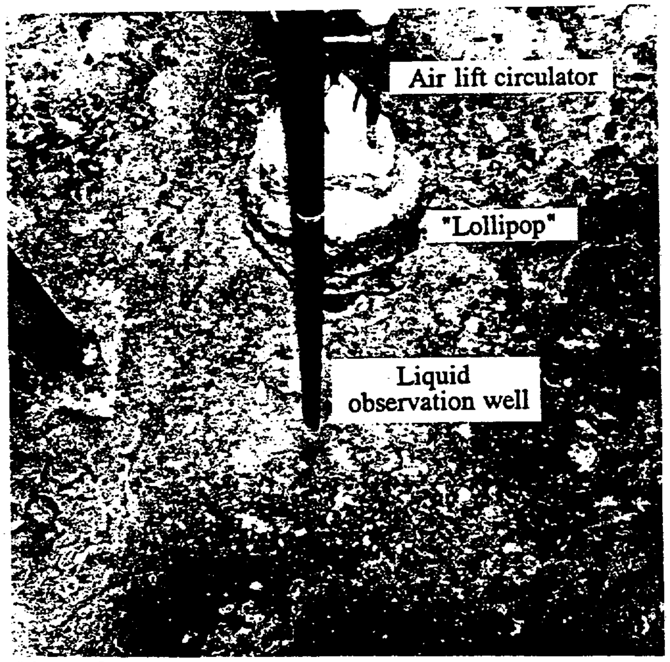

Figure 2.

Liquid Removal Equipment. Historically, there have been two ways of removing liquids from in-tank wastes. One of these methods required localized boiling of the waste with subsequent removal of water vapor by the tank's heating, ventilating, and cooling system. The other method involved pumping the drainable fluids from the waste tanks.

Two types of equipment have been used to concentrate liquid tank wastes by boiling. These are in-tank solidification units (ITSs) and steam coils. ITSs are essentially ALCs with electric-resistance immersion heaters installed inside. The operation of the ITSs is similar to that of the ALCs in that compressed air is used to circulate tank wastes up a large diameter pipe. The rising waste is then boiled as it passes the heaters. Three tanks contain ITSs.

Steam coils consist of a steel framework that suspends columns of 5.1-cm (2-in.) coiled-steel steam lines in the tank waste. This column of coils can vary in height from 1.5 m to 7.0 m (5 ft to 23 ft), depending on design. Existing coil-assembly designs have either two or three layers of coils nested inside each other.

Liquid removal by pumping is done with the riser-installed, salt well screen (Figures 3). The construction of the salt well screen has differed somewhat over time but it usually is made of 6.1 m (20 ft) of 25.4-cm- (10-in.-) diameter carbon-steel pipe with a 6.1-m- (20-ft-) long, 25.4-cm- (10-in.-) diameter stainless steel well screen welded to the end. Salt well screens were installed in the risers so that they reached to just above the tank bottom. Jet pumps placed in the salt well screens remove any liquid that migrates through the waste to the inside of the screens.

Steam coils and ITSs pose the same problems to arm-based retrieval that ALCs do. An additional complication stems from the complex structure of ITSs and steam coils and their enhanced ability to entrain wastes. Salt well screens are large and thus pose a handling problem for the manipulator arm. Although they probably will not contain entrained waste (because of the well screen), photographs show some of them to be cemented into the waste.

Tank Waste Monitoring Equipment. Tank waste within the SSTs is monitored by a variety of different instruments. Among these are liquid-level gauges, thermocouples, and liquid observation wells (LOWs).

In the past, liquid levels were determined in the tanks using weights lowered manually with a stainless steel measuring tape. The system has since been replaced by an automatic version called the FIC, after its manufacturer Food Instrument Company (Figure 4).[2] This instrument consists of a conductivity electrode (a steel plummet) connected to a stainless steel measuring tape. The tape is deployed through a 9.5-cm- (3.75-in.-) diameter steel pipe with an inner sleeve of 5.1-cm- (2-in.-) diameter PVC pipe. A tape reel and controller automatically lower the plummet until contact is made with a liquid waste surface, which completes an electrical circuit through the tank and stops the reel. The controller can provide a readout of the waste height or transmit the reading to a centralized computer.

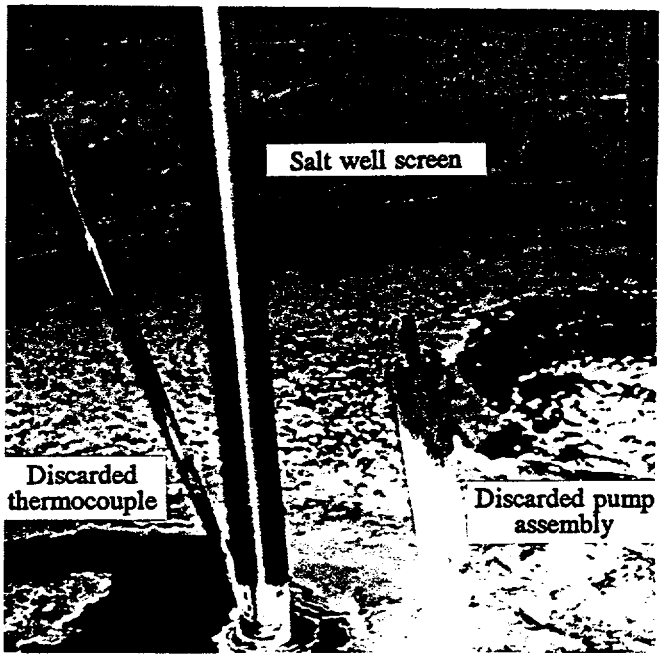

Figure 3.

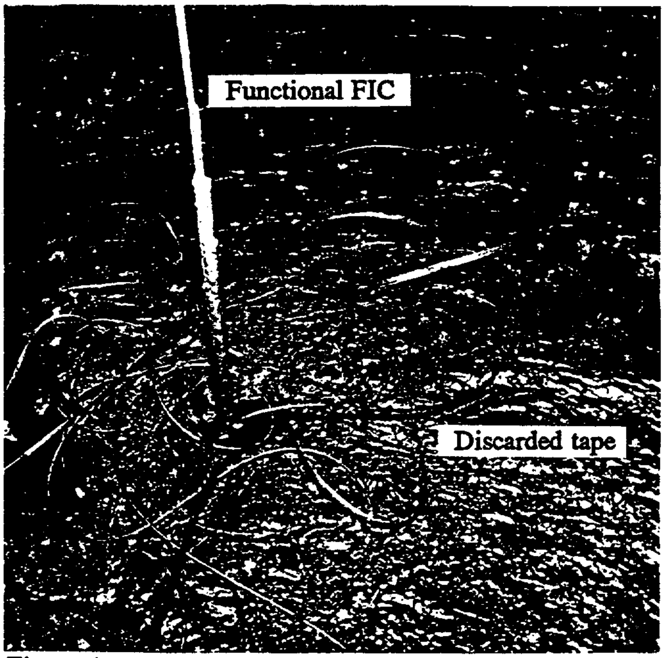

Figure 4.

Waste temperature readings are taken with thermocouples installed in risers (Figure 1). These thermocouples are installed in "probes," which are made of varying lengths of steel pipe with diameters ranging from 1.3 cm to 5.1 cm (0.5 in. to 2 in.).

Liquid observation wells are used to monitor the interstitial liquid level in SSTs. The wells are usually constructed of fiberglass or reinforced epoxy-polyester resin (Figure 2). LOWs are installed through risers and extend to within 2.5 cm (1 in.) of the bottom of the waste tank, are sealed at their bottom ends, and have an outside diameter of 8.9 cm (3.5 in.). Gamma and neutron detectors within the LOWs detect changes in the interstitial liquid levels.[3] Thermocouple probes can also be inserted into an LOW.

Monitoring equipment that has been either cemented in place by the waste or covered with "lollipops" will present difficulties to arm-based retrieval operations. If the equipment is not removed after being freed from the waste, it will be a continual collision hazard throughout the duration of retrieval operations.

Pumps. There are several types of pumps used in the SSTs. Most of them are mounted with their motors in pump pits located above the tanks. The in-tank portion of the pumps is usually encased in steel pipe with a diameter sometimes over 25.4-cm (10-in.). Supporting frameworks of structural steel are associated with some pump types, as are steam lines, hydraulic lines, and other utilities. Some tanks have submersible pumps that can be raised out of the waste with steel cables.

The complex construction of some pumps will hamper the removal of waste "lollipops" that have formed. It is also assumed that the in-tank portions of the pumps have internally trapped waste, which may require disassembly and cleaning by the manipulator. Additionally, there are discarded pumps and pump parts within the tanks that will hamper manipulator movement.

Miscellaneous and Discarded In-tank Hardware. The SSTs have accumulated a variety of miscellaneous material. In the past, materials, used both outside and inside the tanks, that were contaminated during procedures were discarded by dropping them down risers. Also, when failed equipment couldn't be removed by extracting it through a riser, it was cut off and allowed to fall into the waste. This practice freed the riser for installation of replacement equipment. Often found are pump parts, cut-off thermocouple probes, waste- and gas-sampling equipment, lead-shielding bricks, FIC tapes, cables, rocks, protective clothing, fuel rods, and other discreet radioactive sources (Figures 1, 3, and 4).

Although much of the discarded material is small, some of it, like pump assemblies, will exceed the manipulator's payload capacity. Retrieval strategies will have to be developed to effectively deal with these obstructions. For example, large objects will have to be repositioned inside the tank or transported out of the tank in order to expose the waste surface for continued retrieval. This will require special end effectors, such as cutters and grippers, to reduce large pieces to manageable sizes and move them. Specific end effectors may also be needed to deal with FIC tapes, cables, and clothing, which can tangle or jam the arm and/or end effectors.

CONCLUSION

All types of SST ITH will have some degree of influence on robot-based retrieval operations. Especially significant are the hazards generated by each type of ITH. Even if many of the items do not exist in a given tank, at a minimum, the following should be considered in designing and operating the arm: (1) riser-mounted ITH will transmit impact loads to the tank structure if hit by the manipulator; (2) discarded cables and tapes present tangling hazards to the arm and to retrieval tools; (3) ITH may have to be decontaminated and removed from the tanks. Some ITH, like rocks, may force only minor changes in arm design or operation. Pumps, ALCs, and steam coils, however, may require extensive hardware and control system development to address the difficulties in removing encrusted and entrained waste.

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