Conf-841157--50

CLEANOUT OF WASTE STORAGE TANKS AT OAK RIDGE NATIONAL LABORATORY*

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DE85 005274

Submitted for Presentation at

Materials Research Society
1984 Annual Meeting

Boston, Massachusetts

November 26-30, 1984

*Research sponsored by the Office of Defense Waste and Byproducts Management, U.S.Department of Energy under contract DE-AC05-84OR21400 with Martin Marietta Energy Systems, Inc.

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Abstract

In 1943, six storage tanks were built at the Clinton Laboratories [later to become Oak Ridge National Laboratory (ORNL)] to contain wastes generated by wartime research and development operations. During the following years, these tanks became an integral part of the ORNL waste system and accumulated ~1.5 x 10^6 L (400,000 gal) of sludge containing radioactive wastes. Recently, over a period of ~18 months, these tanks were sluiced, the radioactive sludge resuspended, and the resuspended slurry pumped to the ORNL Hydrofracture Facility for underground disposal.

In this paper, a summary of the development work is given, and the process design and constraints are described. The operating difficulties encountered and overcome included grinder blade erosion, malfunctioning instruments, pump suction plugging, and slurry settling. About 90% of the settled sludge (containing ~715,000 Ci) was removed from the system.

Introduction

In 1943, the Clinton Laboratories were built at Oak Ridge, Tennessee, to serve as a pilot plant for production operations at Hanford. The work included the construction of six underground tanks for storage of the wastes generated at the Laboratories. These tanks were in operational use by November 1943. Subsequently, Clinton Laboratories became Oak Ridge National Laboratory (ORNL), and the waste storage tanks became an integral part of the Laboratory's waste system. The waste handled by this system is routinely treated with caustic to a pH of 10 or greater; substances that are insoluble in alkaline solutions precipitate and settle, principally in the waste storage tanks. By 1980, when the waste system was revised and these tanks were no longer being used, they had accumulated ~1.5 x 10^6 L (400,000 gal) of sludge containing the insoluble fraction of the radionuclides that had been generated at the Laboratory. A program to empty the waste tanks and dispose of the accumulated radioactive sludge had already begun (in 1977). Process development, system design, and facility construction were completed by June 1982. In ~18 months of operations, all six tanks were sluiced and ~90% of the sludge was resuspended. This resuspended waste sludge was pumped to the ORNL Hydrofracture Facility for temporary storage and, subsequently, permanent disposal.[1]

Waste Description

The diameter of the waste storage tanks is 15 m (50 ft) with a center depth of 5.5 m (18.25 ft) and individual tank capacity of ~640,000 L (170,000 gal). The tanks were built by spraying a cement slurry against a lattice of reinforcing bars (the Gunite process) for a final wall thickness of 19 cm (7.5 in). A French drain at the base of the outside wall was provided with a leak detection system, but there was no provision for double containment. The interiors of the tanks are relatively uncluttered; there is a pump suction leg and a level probe, but no cooling coils.

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The depth of sludge varied from ~30 cm (1 ft) found in three tanks to 3 m (10 ft) in one of the tanks. Chemical and radiochemical analyses of sludge samples showed great variability among the tanks, between different levels in the same tank, and even between supposedly duplicate samples taken from the same level in the tank. Data collecting through inventory sampling showed the major elements in the tanks to be uranium, iron, thorium, calcium, and aluminum. The primary radionuclide (representing 95% of the total activity) was ^{90}Sr. Analyses indicated ~2 x 10^6 Ci of ^{90}Sr (which was later shown to be an overestimate), and 4,500 Ci of TRU isotopes (about 10 times higher than estimates based on accountability records). Radionuclide assays subsequently done in support of disposal operations indicated ~730,000 Ci of ^{90}Sr and 2,500 Ci of TRU isotopes. These figures are about half the estimates generated by grab sampling prior to sluicing. The lower figures are considered to be the more accurate, because they represent measurements made on samples from the "homogenized" sludge.

Process Development

Laboratory tests indicated that ~50 wt % of the sludge consisted of small particles (diameter < 10 μm), which settled slowly in water. Tests on a separated fraction of the particles larger than 10 μm in diameter showed that they were quite friable. A series of laboratory and field tests with simulated sludges and hot-cell tests with actual sludges demonstrated that:[2]

(1) the sludge agglomerates could be reduced to < 20-μm size with a commercially available grinder;
(2) sludge particles < 20 μm in diameter would not settle for several days if dispersed in a 2.5 wt % bentonite suspension.
(3) slurries containing 2.5 wt % bentonite could be pumped at concentrations up to 25 wt %.;
(4) a single sluicer mounted high in each tank could be used to resuspend the sludge;
(5) instrumentation was a problem because most available instruments would not work on slurries under field conditions; and
(6) vision into the tank during sluicing would be essential to monitor process operation.

A diagram of the batch process used for emptying the waste tanks is shown in Fig. 1. In this process, a bentonite suspension is continuously pumped between the tank being sluiced and a near-empty waste tank located nearby. Initially, a 150,000-L (40,000-gal) batch of 2.5% bentonite suspension in water is mixed and collected in the near-empty tank that serves both as a feed tank and as the container for the resuspended waste sludge. This suspension is then pumped through a remotely controlled sluicer nozzle to impinge on the sludge in the waste tank being emptied. The impact of the jet stream breaks up the settled sludge and resuspends the individual particles while the bentonite suspension hinders settling. The resuspended sludge is pumped from the waste tank through a grinder that breaks up oversized particles, and returned to the feed tank. This operation continues until the sludge concentration in the feed tank approaches 15 wt %. At this point, the sluicing is stopped, and the slurry in the feed tank is pumped to storage. A new batch of bentonite feed suspension is then prepared, and the cycle is repeated until the waste tank is judged empty.

Process Equipment

The equipment required for the sluicing operation included a bentonite makeup system, a remotely controlled sluicer assembly, a grinder to reduce

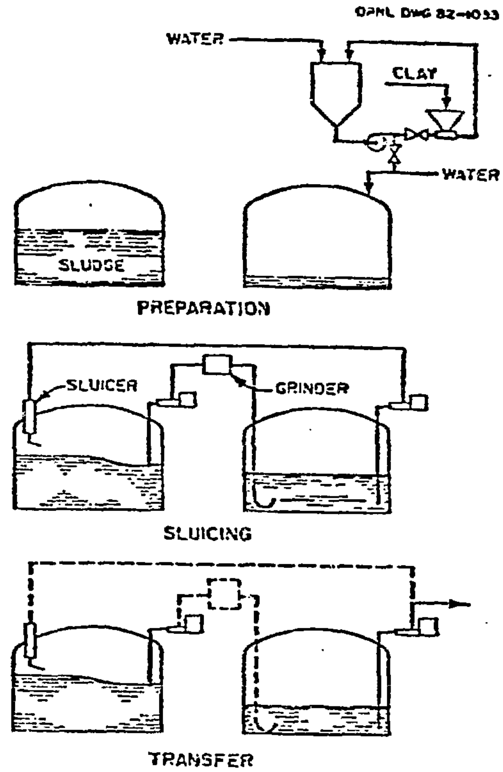

Fig. 1 Sketch of process concept.

oversized slurry particles, and two Moyno pumps for slurry transfer between waste and feed tanks.

An adjustable suction pump leg was provided for the tank being sluiced, so that it could be extended as the sludge was removed from the tank. Because the structural strengths of the tank domes were unknown, all equipment that had to be mounted above a tank was supported on a platform that straddled the tank being emptied. This arrangement is shown in Fig. 2. The necessary penetrations into the tanks were made by a drilling rig mounted on a platform going through a caisson cemented to the tank dome. A grinder and two slurry pumps were installed in pits adjacent to the tanks. All slurry piping was contained within a larger pipe, to limit the spread of contamination in the event of a leak. Most slurry lines were buried and the others were shielded to minimize radiation exposure.

System instrumentation included a Densometer (Halliburton Co. - Special Products Division) to measure slurry density, a vibrating-rod viscosity meter, a system of bubblers designed to measure slurry density at several levels in the feed tank, and a TV camera to monitor sluicing progress. An additional measurement of slurry concentration was obtained when the resuspended slurry was pumped from the feed tank to storage prior to disposal. The transfer line was long enough (about 1,800 m (6,000 ft)) to serve as a pipeline viscometer. Pressure drop was measured at several pumping rates during transfer, and the apparent viscosity of the slurry was calculated from these data. This apparent viscosity could be related to the solids content of the slurry, so the determination provided a quick and reliable check on the concentration being pumped to stora

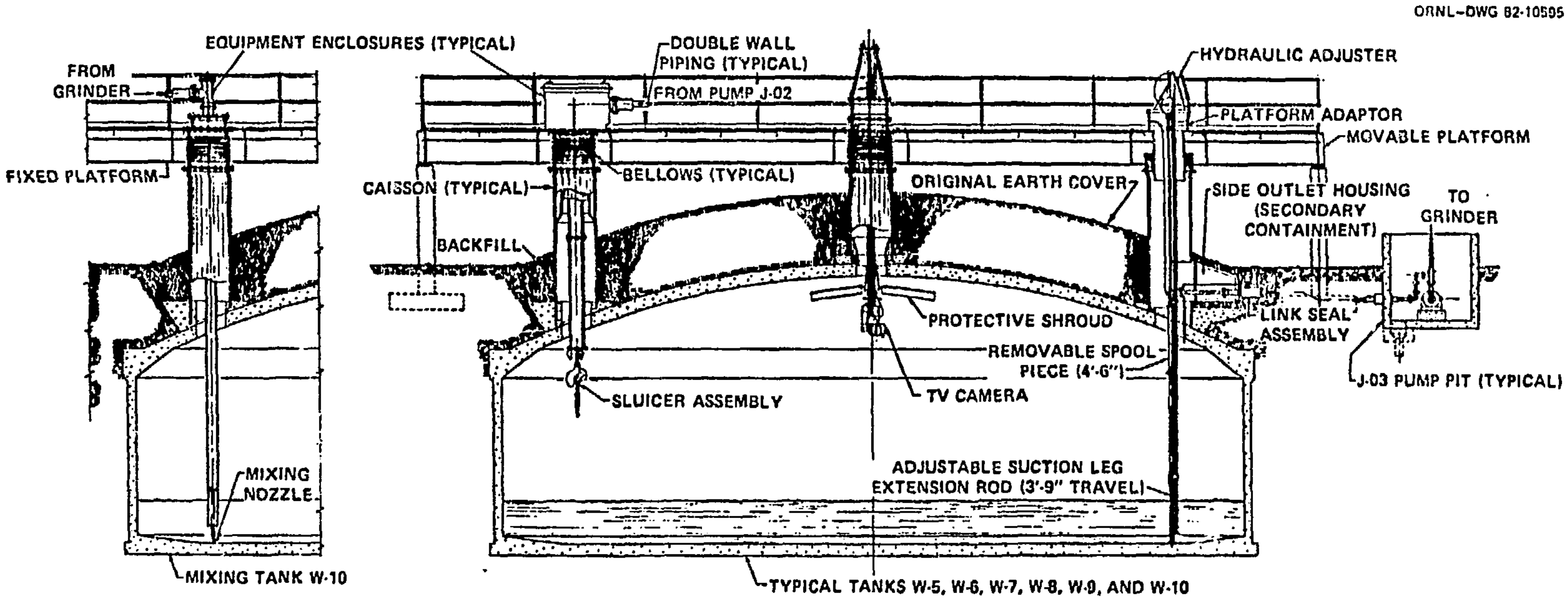

Fig. 2 Arrangement of tank sluicing equipment.

A photograph of the operation is shown in Fig. 3. The feed tank and its operating platform are in the foreground. In the middle background are the tank being sluiced and its operating platform; the crane is shown removing the TV camera for repair. To the left of the tank being sluiced is the drilling rig on the operating platform of the next tank scheduled to be sluiced.

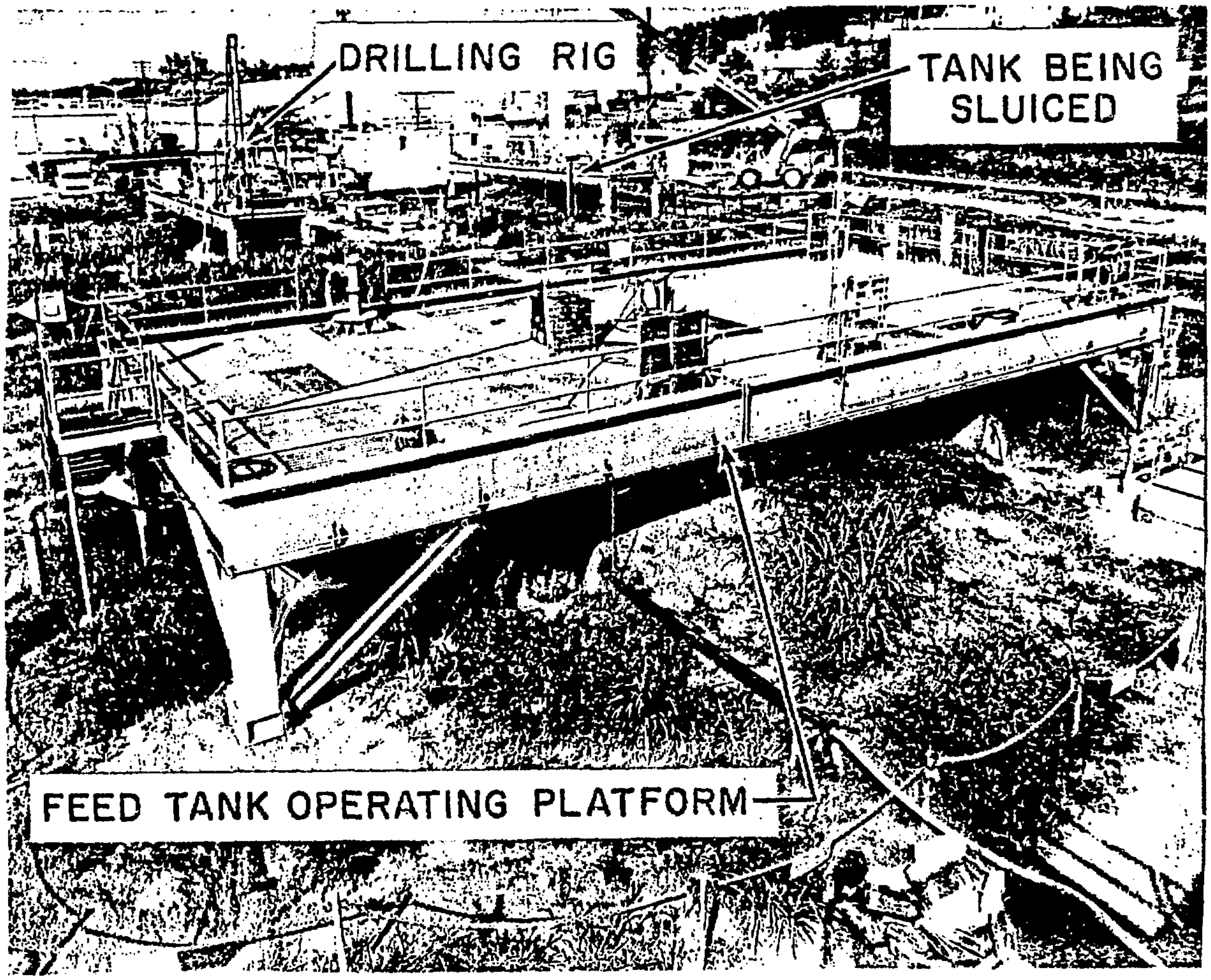

Fig. 3 View of sluicing operations.

The tanks were sluiced in sequence; while sluicing of the first tank was in progress, the penetrations were being drilled in the next tank to be sluiced. When sluicing of the first tank was completed, the sluicing equipment (sluicer, pump suction leg, and TV camera) was moved to the next tank and connections to process piping, service piping, and instrument lines were made. The platform for the first tank was then moved to the third tank in the sequence and operations resumed.

Operations

The cleanout schedule was determined by the availability of the disposal facility, the achievable concentration of the resuspended sludge, and the time rquired to move and set up the sluicing equipment. On the basis of these factors, it was estimated that the resuspension and transfer of the sludge from the six waste tanks would require 13 months.

Sluicing operations on the first of the waste tanks began on July 12, 1982. Concurrently, drilling operations were started on the next tank in the sluicing sequence. A total of 36 sluicing operations were required to resuspend the sludge in the six waste tanks and transfer this sludge to the disposal facility. During the first few of these sluicing operations, the solids concentration of the resuspended sludge was far below the desired value (less than 5 wt %). This was the result of several factors - improperly functioning instruments, frequent plugging of the pump suction jet, and a lack of process experience by both the operators and the supervisors. As operating experience was gained and some field modifications made to equipment and procedures, a considerable increase in solids concentration was achieved by the fifth sluicing operation (up to 20 wt %).

Most of the instrumentation for measuring slurry density did not work as planned. As a consequence, it was difficult to determine the progress of the sluicing operation and, because there was nervousness about possible plugging of the transfer line if the slurry concentration got too high, the normal tendency was to stop sluicing and transfer the resuspended sludge too soon. The slurry viscosity measurements that were made during the transfer provided an accurate measure of the slurry concentration and were an extremely useful check on the other methods that were being used for this purpose.

During the first several sluicings, it was observed that the screen on the bottom of the pump suction leg was frequently plugged by sample bottles, plastic gloves, and other trash in the waste tank. A new footpiece with a vertically mounted screen that could be washed by the sluicer jet whenever plugging occurred, was designed and installed. This change greatly improved system operation.

After several sluicings had been completed, the grinder abruptly stopped. It was found that the grinder blades had been eroded by the slurry, causing several of the smaller teeth to break loose and shear off additional teeth. The grinder was reassembled with a new set of blades, and sluicing was resumed. Thereafter, the grinder blades were replaced periodically.

During the sluicing of this first tank, the 1.6-cm (5/8-in) jet on the sluicer assembly was removed and replaced with a 1.3-cm (1/2-in) jet. The smaller jet operated at higher pressure and had a considerably greater impact force. The large agglomerations of sludge solids that were being exposed by the sluicing operation at this stage appeared to be more readily broken by this jet stream.

A view of the interior of a waste tank during sluicing operations is shown in Fig. 4.

After several sluicing operations and the associated transfers of the suspended waste to the hydrofrature disposal facility had been made, it became clear that the agitation of the resuspended sludge in the feed tank was inadequate, and some solids were settling from suspension. The rate of settling was low, but the cumulative volumes were large; ~238,000 L (63,000 gal) accumulated in the feed tank during the sluicing of the remaining tanks. This settled sludge was resuspended again and transferred

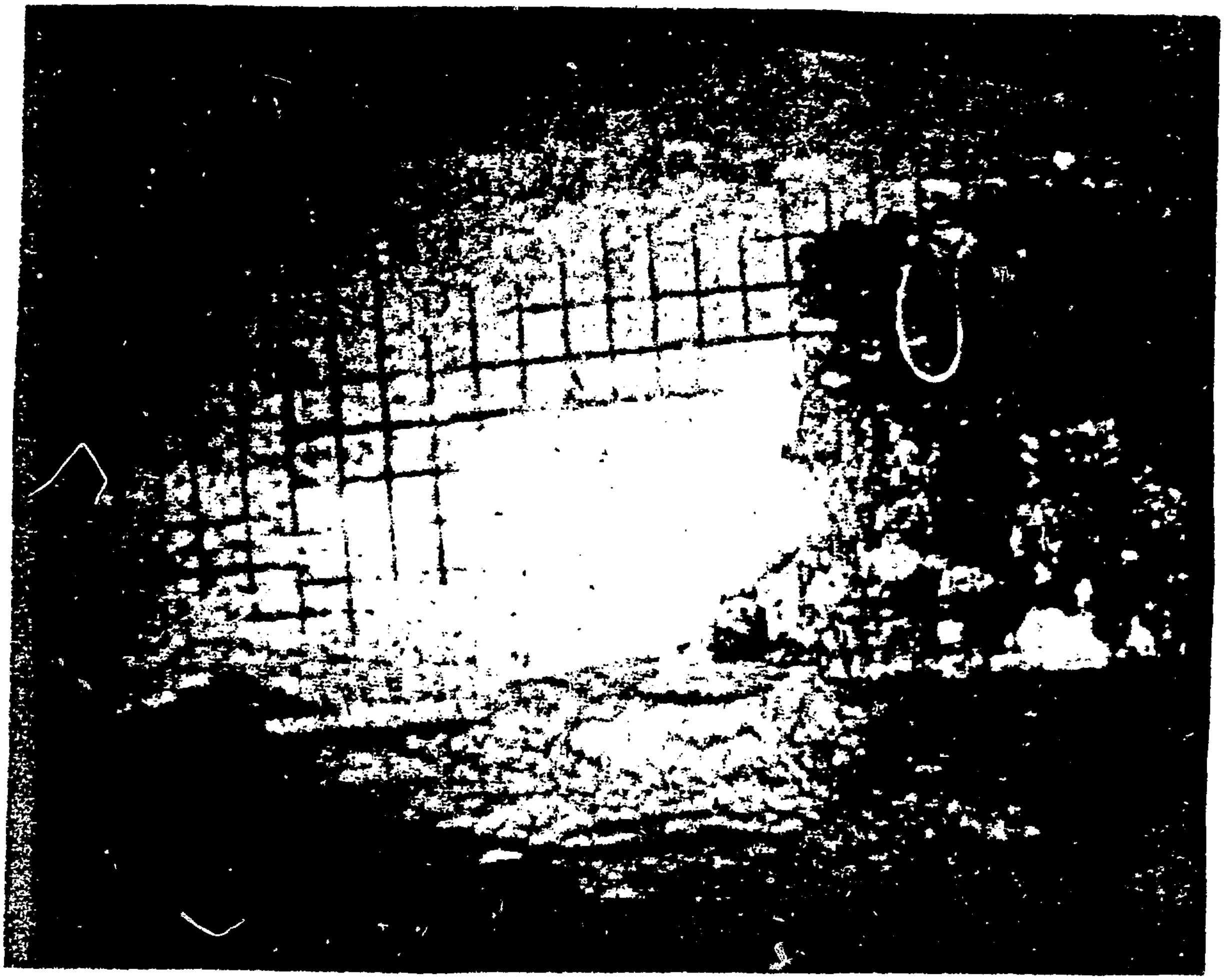

Fig. 4 Interior of waste tank during sluicing.

to the waste tanks at the disposal site when the feed tank was sluiced (the last tank in the sequence). The net effect of the settling, therefore, was a built-in operating inefficiency.

Summary

Calculations indicated that the weight of the sludge solids transferred from the six waste storage tanks was ~40% more than was originally thought to be there. Radionuclide assays indicated that ~ 730,000 Ci of ^{90}Sr and 2,500 Ci of TRU isotopes were removed from the tanks. Each of these values is approximately half the values estimated from analyses of grab samples prior to the sluicing operations.

The hydrofracture well used for final disposal of the waste sludge was discovered to be plugged in December 1982, and subsequent well recovery operations required approximately four months. Sluicing operations in the waste storage tanks were suspended during this time. Operations were resumed in April 1983 and continued without serious difficulty until completion in January 1984.

A comparison of the actual operating schedule with the planned schedule shows that the transfer of equipment between tanks took less time than estimated, while the sluicing process took somewhat longer than planned (largely because the sludge volume was greater than anticipated). The sluicing operations were completed ~4 months later than originally scheduled because of the unplanned, 4-month shutdown of the hydrofracture disposal facility.

Acknowledgments

Many people at ORNL have been involved with the waste tank sluicing operations from their conception to the completion of operations. The process design and development represent cooperative efforts by ORNL staff members of the Chemical Technology Division and the Operations Division. Operations Division personnel were also responsible for facility operation with assistance provided by staff members from the Chemical Technology and Plant and Equipment Divisions. Equipment design was the responsibility of the Engineering Division.

References

[1] Disposal of Radioactive Grouts into Hydraulically Fractured Shale Technical Reports Series No. 232 IAEA, Vienna, 1983.

[2] H. O. Weeren and T. S. Mackey, Waste Sludge Resuspension and Transfer - Development Program, Oak Ridge National Laboratory, ORNL/TM-7125 (1979).