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Abstract for

PERFORMANCE ASSESSMENT OF THE WASTE DISLODGING AND CONVEYANCE SYSTEM DURING THE GUNITE AND ASSOCIATED TANKS REMEDIATION PROJECT

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The Waste Dislodging and Conveyance System (WD&C) addresses the need for removal of hazardous wastes from underground storage tanks in which radiation levels and access limitations make traditional waste retrieval methods impractical. This system is comprised of a number of different components. Three of the primary components include the Confined Sluicing End-Effector (CSEE), Hose Management Arm (HMA), and Flow Control Equipment Box (FCE). The WD&C system is not a stand-alone unit; rather, it is designed for deployment with either a long-reach manipulator or a remotely operated vehicle system such as the Houdini™.

The CSEE was designed by Pacific Northwest National Laboratory, Oak Ridge National Laboratory, and Waterjet Technology Inc. (WTI) and built by WTI. The CSEE is a sluicing end-effector equipped with three rotating cutting jets mounted 120 degrees apart. The jets, which are capable of delivering water at pressures of up to 10,000 psi, nearly converge at a point about two inches below the conveyance line intake on the end-effector. As the jets rotate, hard waste is dislodged, vacuumed up through the center of the CSEE, and into a 2 in.-ID hose under the motive force provided by a jet pump mounted upstream in the mast of the HMA. A higher-pressure variation of this end-effector, the Gunite Scarifying End-Effector (GSEE), was also developed to scour the tank walls after the bulk sludge was removed from the tank floor.

The HMA was designed to act both as a pipeline for the transfer of dislodged waste, and as a hose-positioning system. ORNL and staff from The Providence Group, Inc. designed the HMA to provide access to all points within a 50-ft or smaller diameter tank. The arm has four degrees-of-freedom (DOF): mast vertical travel, mast rotate, shoulder pitch, and elbow yaw. The mast is constructed of a half section of 20-in diameter, carbon steel pipe with a flat plate welded across the half section as a seal. The mast houses a variety of pipes and instrument cables, the CSEE and jet pump's motive water, the jet pump, and the waste conveyance line.

The FCE attaches to the HMA and is equipped with sluicing discharge piping--including valves for flow control, flushing, and automatic sampling of the waste being retrieved. Instrumentation in the FCE allows discharge flowrate and density to be measured as well.

Since June 1997 the Waste Dislodging and Conveyance System has been successfully used as part of the Gunite and Associated Tanks (GAAT) Remediation Project to inspect and retrieve waste from numerous DOE tanks on the Oak Ridge Reservation. These gunite tanks range from 25 to 50 feet in diameter and, at the onset of the GAAT project, collectively contained about 88,000 gallons of radioactive sludge and solids and approximately 250,000 gallons of liquid. Total radioactivity was estimated at 63,000 Ci of various isotopes.

Various components of the WD&C system were delivered to ORNL during the summer of 1996 and integrated into a complete system by September 1996. Several months of cold testing ensued, during which time the equipment was integrated with two other remote retrieval systems—the Houdini Remotely Operated Vehicle and the Modified Light Duty Utility Arm (MLDUA). Relocation of the WD&C system to the GAAT site was initiated in June 1997.

As of May 2000, the WD&C System, with assistance from the MLDUA and Houdini systems, succeeded in removing approximately 95% of the curie content and 99% of the sludge waste from six of the seven gunite

tanks scheduled to be cleaned by the remote systems. The HMA was operated for over 600 hours during this time.

As soon as the initial sampling operations were completed in each tank, the HMA and CSEE were deployed. Either the MLDUA or the vehicle had to be present to grasp the CSEE as the HMA was deployed in order to keep the end-effector's nozzles from plugging in the waste material on the bottom of the tank. The water lines for flushing the nozzles could not be connected at the masthead until the mast was fully deployed into the tank.

Normally, the first few days of sluicing were spent dewatering the tanks. During this time, the CSEE cutting jets were operated at low pressures (~150 psi) to prevent nozzle plugging while the supernate was drawn off using the jet pump. Once the sludge layer was revealed, pressure to the cutting jets was increased as necessary to break up and suspend the waste material for sluicing.

The WD&C system was most efficient at removing sludge when the waste material was deep enough to partially submerge the CSEE, thereby avoiding three-phase (solid, liquid, gas) pumping. When down to the last 1-3 inches of tank waste, the most productive method of operation was to have the Houdini collect and plow "waves" of waste to the end-effector as it was held by the MLDUA. Generally, once sluicing operations were completed, wall scarifying was initiated. In tanks W-3 and W-4, the CSEE was used to scarify the tank walls at pressures of ~6500 psi. The GSEE was used in the remaining tanks once an ultrahigh pressure water pump became available. Although pressures of up to 36 ksi were possible with the new pump, the MLDUA was unable to handle the reaction forces at pressures of greater than 20 ksi.

The performance of the WD&C System between June 1997 and the completion of the GAAT project in September 2000 will be discussed in detail in this paper. Overall, the system performed quite reliably, although as Oak Ridge operators gained more experience with the remote retrieval systems, a number of innovations for improving operations were defined and implemented. These changes will also be described in the full paper.