Using Commercially Available Robotic Equipment to Sample and Remove Heels in Tanks with Internal Obstructions- 11239

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ABSTRACT

Removing deposits of insoluble sediments and the sampling of any deposits that can not be removed from highly radioactive storage tanks is a part of the tank closure program. The deposits are small quantities of insoluble solids left in the tank after numerous mechanical and chemical cleaning evolutions. These Waste Tanks are congested with cooling pipes and other obstructions, limiting cleaning techniques and impacting sampling. Using a small, commercially available crawler in these tanks was originally deemed impractical given the significant obstructions created by the serpentine coils and other obstacles. However, a miniature crawler obtained from a commercial supplier was adapted from one used for tank sampling with abutments that allow limited and controlled maneuvering around and over the tank coils without getting tangled. An on-board vacuum eductor is being designed with off-the-shelf components using high-pressure water to create the vacuum necessary to capture and transport the sediment.

INTRODUCTION

As part of an accelerated tank closure program, the Department of Energy (DOE) at the Savannah River Site (SRS) intends to remove from service and operationally close 22 waste tanks within 8 years that do not meet current containment standards. This is an aggressive schedule considering that in the more than 50 years of operation of SRS, only two tanks have been operationally closed and grouted.

The single shell High Level Waste tanks targeted for closure were constructed from commercial grade carbon steel in the mid-1950's to the early 1960's. In general, their dimensions range from 23 to 26 meters in diameter, 7 to 10 meters high, and the volumetric capacity ranges from 2.8 to 4.9 million liters. Typically, each tank contains an internal labyrinth of cooling coils made from carbon steel, which further complicates waste removal, cleaning, and closure. Access to these tanks is restricted to a few openings, typically 8 of approximately 0.6 meters in diameter.

BACKGROUND

Historically the collection of samples or the retrieval of sediment remaining in the tanks has been through the use of long reach tools. These tools restrict the available area for sampling or material retrieval. When samples or material retrieval is required from areas not located directly under an access riser (off-riser), unique one-of-a-kind robotic devices were designed and built for sampling or material removal in one application or deployment. These robotic devices tend to be expensive and are time consuming to design, build and test. As part of obtaining the final representative samples for Tank 18 and Tank 19, it was recognized that some of the sample locations would be off-riser. The sample locations would require special separation in order to obtain representative samples of the remaining material in the tank. Most of the sample locations were not located under the access ports (risers). Original thoughts were to deploy long reach tools that would articulate for performing scrape sampling of the residual material in the tank. In order to obtain samples from the desired areas, some of the risers would require dismantlement and removal (D&R) prior to sampling due to failed equipment that was abandoned in the riser. The equipment and riser area were heavily contaminated and the radiation exposure was very high. The cost, as well as the radiation exposure to personnel during the D&R led to the investigation of alternate techniques for obtaining the required samples. During the planning phase of the sampling effort, a commercial pipe inspection robotic platform was identified as a possible solution, eliminating the required D&R of the risers and would meet the requirement to obtain the samples from various areas in the tank. The robotic platform was originally developed for internal video inspection of commercial piping systems. The crawler could be used underwater, in soil and debris situations and has radiation hardened electronics.

Fig. 1. Commercial inspection crawler

The commercial crawler was modified by replacing the video camera and lighting equipment with a pneumatic sampling device. The sampling device consisted of a dual pneumatic cylinder with a pinned connection for the sampling container. The cylinders were operated with low pressure air supplied by air lines strapped to the control tether. The crawler was hoisted in and out of the tank after each sample. The modifications were design, constructed and tested by in-house project engineering and maintenance personnel. Once final modifications were completed, the crawler dimensions allowed entry into the tank via the 0.6 meter openings. Sampling in Tank 18 and Tank 19 was completed with the crawler obtaining all the necessary samples from the locations specified.

With the successful completion of sampling in Tanks 18 and 19, utilization of a small crawler was determined as the desired device for future tank sampling of tank residual sediment.

Fig. 2. Commercial crawler after sampling modifications

DEVELOPMENT

After the mechanical cleaning in Tank 5 was completed, a small amount of sediment was remaining in the tank. It was surmised that the small amount of remaining sediment would have to be removed from the tank in order for the tank to meet regulatory requirements for closure. This sediment accumulated under two of the riser openings and under the cooling pipes in the tank. An Engineering Evaluation [1] was performed to determine the most feasible technology for this additional sediment removal. The study concluded that a crawler based system had the highest likelihood for removing the remaining sediment. Using a crawler was originally deemed impractical given the significant obstructions in the tank created by the cooling pipes and equipment. However, the sampling crawler utilized in Tank 18 and Tank 19 demonstrated that the small crawler could traverse over hoses and with simple modifications, the crawler could be used in a tank with obstructions.

Again, to minimize cost and schedule design, modifications and testing were performed in house utilizing project engineers and maintenance mechanics. The original platform and drive train for the sampling crawler were modified to transport the retrieval system.

Development of the retrieval system was a risk mitigation tool and a tool for future use if tanks were not cleaned as well as expected. Preparation of an expedited schedule to support regulatory commitments did not allow use of the usual conceptual, preliminary and final system design development. The challenge for the team was to have a working system in place within an approximately 3 month time frame.

SYSTEM DESCRIPTION

The development of the material retrieval crawler began after landing on a crawler/eductor concept. The material retrieval crawler can be broken down into two different design elements, the crawler platform and an eductor.

The purpose of the eductor is to create a suction area near the bottom of the crawler in order to transport the sediment from one waste tank to another. The final design of the eductor utilized high pressure water as the motive force picking up the solids and transporting them to the receipt tank. The eductor was suspended in the tank and its suction is attached to an articulating arm on the crawler in order to move the suction hose forward and backward independent of crawler operation.

The crawler platform holds three cameras for driving and viewing the suction opening, the suction hose with actuator, and cooling coil skids (or skis). During development of the crawler, it was determined through testing that the crawler tracks alone would not allow the crawler to traverse over some of the cooling pipes on the bottom of the tank. A test facility representing ¼ of the tank was built to scale to allow for testing of the crawler's mobility. Cooling coil pipes were installed in the test facility and development of the skis to allow the crawler to traverse around the bottom of the mock-up tank was completed.

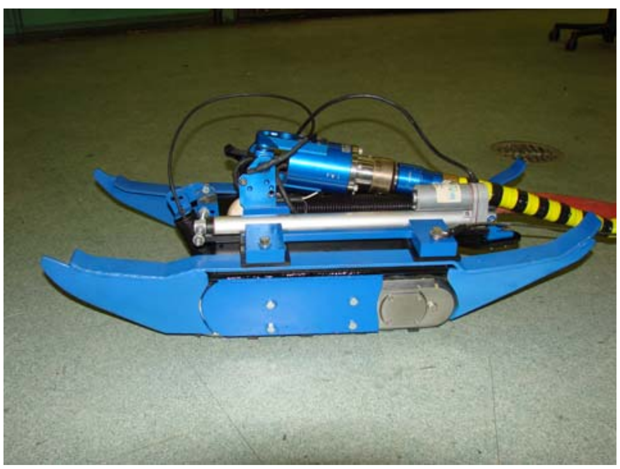

Fig. 3. Material Removal Crawler

Due to the time restrictions for deployment, many different configurations for the eductor, suction line and crawler platform were attempted until a final layout was determined. This layout utilized off the shelf components to minimize delivery time. As such, the final design of the crawler is short of becoming a prototype that would be used for multiple tank deployments

The biggest challenge identified during the development of both the sampling and material removal crawler was managing the tether/suction hose during deployment. While sampling the tether/airline became tangled and had to be untangled remotely by either driving the crawler to untangle the lines or utilizing long reach tools from the tank top. The material removal crawler was bogged down during testing due to the weight of the suction hose in conjuction with the damp consistency of the test material on the steel bottom of a test tank. The eductor location (hanging in the tank) and the suction line from the eductor to the crawler significantly restricts the available area that the crawler can travel. Continued refining of the eductor/suction hose assembly is warranted in order to mature the material removal crawler into a reliable tool.

FUTURE DEVELOPMENT

The deployment of the sampling crawler, and the development and testing of the material removal concept crawler demonstrated that a small crawler could be used within a tank with obstructions. The attributes that were developed for the material removal crawler to traverse over cooling pipes (the skis) have been further developed and are being deployed on another commercial off-the-shelf crawler for sampling in tanks that have cooling pipes and obstructions. This sampling crawler, currently under development, will provide another tool in the sampling of waste tanks.

CONCLUSION

Development and deployment of robotic sampling and material retrieval crawlers within SRR has progressed from expensive one-of-a-kind single function crawlers to small, commercially available crawlers that are modified by field engineers and maintenance mechanics. These crawlers allow for the sampling of the waste tanks to satisfy regulatory requirements as well as provided the foundation for continued development of a limited material removal system. These crawlers will continue to be developed to achieve a system that can be deployed in a short amount of time without expensive research and development effort. Efforts will also continue to develop the mechanical cleaning crawler system, refining the parts and improving the eductor/suction interface to allow the crawler to operate effectively inside a congested tank.

ACKNOWLEDGEMENTS

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REFERENCES

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