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DEVELOPMENT OF A HIGH LEVEL WASTE TANK INSPECTION SYSTEM (U)

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ABSTRACT

The Westinghouse Savannah River Technology Center was requested by it's sister site, West Valley Nuclear Service (WVNS), to develop a remote inspection system to gather wall thickness readings of their High Level Waste Tanks. WVNS management chose to take a proactive approach to gain current information on two tanks that had been in service since the early 70's. The tanks contain High Level Waste, are buried underground, and have only two access ports to an annular space between the tank and the secondary concrete vault. A specialized remote system was proposed to provide both a visual surveillance and ultrasonic thickness measurements of the tank walls. A magnetic wheeled crawler was the basis for the remote delivery system integrated with an off the shelf Ultrasonic Data Acquisition System. A development program was initiated for Savannah River Technology Center (SRTC) to design, fabricate and test a remote system based on the Crawler. The system was completed and involved three crawlers to perform the needed tasks, an Ultrasonic Crawler, a Camera Crawler and a Surface Prep Crawler. The crawlers were computer controlled so that their operation could be done remotely and their position on the wall could be tracked. The Ultrasonic Crawler controls were interfaced with ABB Amdata's I-PC, Ultrasonic Data Acquisition System so that thickness mapping of the wall could be obtained. A second system was requested by Westinghouse Savannah River Company, WSRC to perform just ultrasonic mapping on their similar Waste Storage Tanks, however the system needed to be interfaced with the P-scan Ultrasonic Data Acquisition System.

Both remote inspection systems were completed 9/94. Qualifications tests were conducted by WVNS prior to implementation on the actual tank and tank deployment was achieved 10/94. The second inspection system was deployed at WSRC 11/94 with success and the system is now in continuous service inspecting the remaining High Level Waste Tanks at WSRC.

INTRODUCTION

In the late 1940s, the United States Government established the policy of producing special materials on a production basis for use in national defense programs. Several years later, nuclear technology that was developed by the U. S. Navy was extended into the commercial sector for production of electrical power. During this forty year plus time frame, both the government and commercial programs have produced a large volume of stored legacy materials.

Today, the government and the private sector are emphasizing environmental stewardship and remediation of production sites. This shift in priorities from defense production to waste management is causing many companies and sites around the nation to refocus their resources onto the safety aspects of processes and equipment that may have been previously taken for granted. One element of this shift is the integrity of tanks and vessels that are being used for the storage of radioactive waste materials. One site, of many, that has taken a proactive approach to acquire current information on their waste storage tanks is the West Valley Development Project (WVNS) at West Valley, New York, which is managed by Westinghouse West Valley Nuclear Services (WVNS).

BACKGROUND

The West Valley Development Project was constructed in the early sixties as a processing facility for spent commercial nuclear fuel. A central element of the project was two carbon steel storage tanks. The Savannah River Site was constructed in the early fifties as a processing facility for weapons grade nuclear materials. A by-product was High Level Wastes that have accumulated over the years and are stored in several Underground Storage Tanks. Both sites now have the same mission to take these legacy materials and process them into glass. Each site has their own vitrification facility in the final testing stages.

The tanks at both sites are similar in geometry and accessibility. They are about 70' diameter by 27' high and located under approximately eight feet (2.4 M) of overburden. The WVNS tanks are enclosed in concrete vaults to provide secondary containment and the tanks at WSRC are enclosed in a second steel tank to provide the secondary containment. The tanks were built with an upper and a lower knuckle section to provide better transition from the tank's shell to the roof and the flat bottom. The primary containments were constructed of mild carbon steel to the requirements of API 650 construction code and were post weld heat treated subsequent to completion of construction. Access to the annular space between the primary and secondary containments is limited to access ports that penetrate the roof of the secondary containments, 10 inch diameter ports on the WVNS tanks and 8 inch diameter ports on the WSRC tanks.

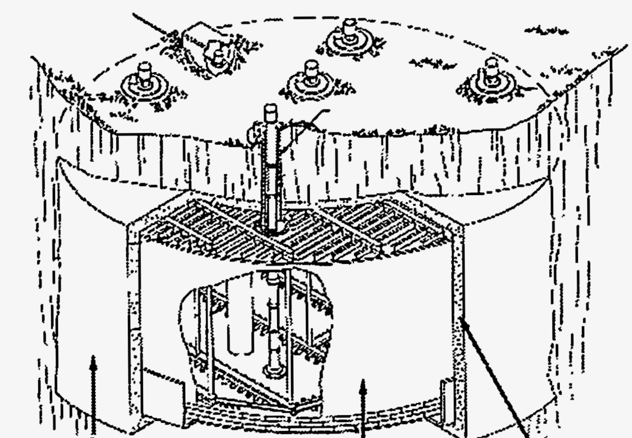

Figure 1. Underground Storage Tank for High Level Waste. Dimensions are similar to above ground Petroleum Storage Tanks.

The radioactive decay of the waste, along with their geometry, make the tanks inaccessible to inspection personnel.

In late 1992, WVNS management chose to take a proactive approach to gain current information on both storage tanks. WVNS partnered with (WSRC) to develop and deliver a remote nondestructive examination system that could acquire both visual and volumetric information on the underground tanks. The project was started in early 1993 with delivery of the equipment to WVNS in late summer of 1994.

DEVELOPMENT

WVNS is one of the smaller DOE sites with adequate operating resources but limited equipment development capabilities. In late 1992, WVNS became aware of the robotic inspection equipment that was developed and delivered by the Savannah River Technology Center (SRTC) of Westinghouse Savannah River Site. Since SRTC had prior experience with remote inspections and could make existing equipment available to WVNS at no cost, a cooperative agreement was reached between WVNS and SRTC to develop a remote delivery system that could acquire the needed data and would align with the DOE objectives of cost-sharing between sites.

The WVNS approach was to use existing codes and guidelines as much as possible to define the inspection requirements. To meet this objective, the requirements of ASME Section V Article 5 and of the "Proposed Nondestructive Examination (NDE) Standard for High Level Waste Tanks" were incorporated into the project.
The design parameters for the equipment called for deployment of the system through a 10" (25.4 cm) inspection port and survivability in a 100% humidity corrosive environment with temperatures up to 175°F (80°C) and calculated radiation fields up to 6,500 R/Hr. Since the surface conditions of the tanks were not well known, a surface cleaning capability was also needed in addition to the ability to acquire visual and volumetric information.

After consideration of several options, the development team arrived at a system that would use a magnetic wheeled vehicle that could deliver different attachments to the area of interest. The vehicle or 'Crawler' would have four 50 pounds-force permanent neodymium magnetic wheels to provide the holding power and two drive trains for mobility. A stainless steel leaf spring would connect the left and right drive trains and would provide compliance to allow navigation over rough surfaces. The leaf spring would also provide the base for mounting different attachments.

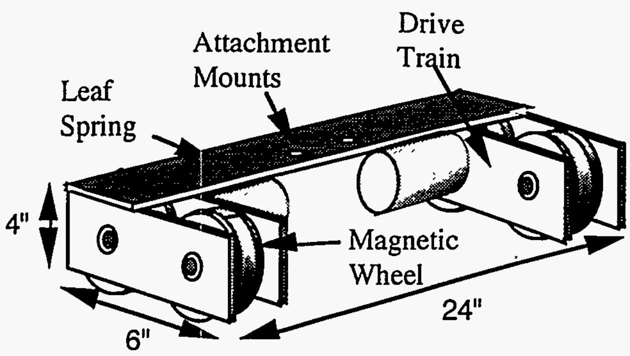

Figure 2. Basic Magnetic Wheeled Crawler

Each crawler would have encoded feedback from each wheel to provide position information and would be steerable by a "joystick" or by programmable computer software. All electrical and moving components would be sealed or encased for water and dirt resistance. The umbilical cables would include an emergency retrieval cable and would be attached to the crawler by a swivel to minimize side loadings. A system of air jets would be mounted over the magnetic wheels to remove any build-up of dirt and rust. Three attachments would be needed; the ultrasonic (UT) scanning attachment, the video attachment, and the surface preparation attachment. Each attachment would be mounted on a crawler and the system configured to allow simultaneous deployment of all crawler/attachment combinations.

The Ultrasonic Crawler provided spring-loaded compliance to maintain transducer contact with the wall. The scanning action was provided by a ball screw to drive the transducer in the "Y" direction while the "X" direction was provided by forward indexing of the crawler. A black and white camera provided a view of the transducer in contact with the wall to allow the operator to see the condition of the surface being scanned. An onboard reference block was used for the "parked" position of the transducer and to provide system reference checks. The UT crawler was integrated to a commercial UT data acquisition system and could be controlled manually or by the programmed UT system.

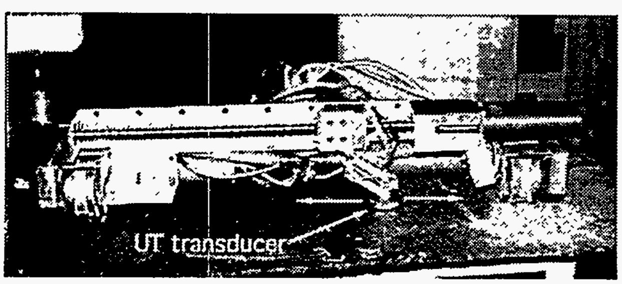

Figure 3. The Ultrasonic Crawler. The UT transducer is moved back and forth with a ball screw drive.

The Camera Crawler provided capability to monitor the operation of other crawlers and to obtain visual information from the areas of interest. The video attachment includes three cameras; a side-looking radiation-hardened camera, a forward-looking black and white camera for navigation, and a second black and white camera mounted on an arm that can elevate the camera to 24" (61 cm) above the surface. The arm has two articulating joints that allows the camera on the end to be elevated above the surface for better general surveillance and can also swing the camera all the way down to view the tank surface up close. Six lights were also part of the attachment providing over 50 watts of lighting for viewing in the pitch dark annular space.

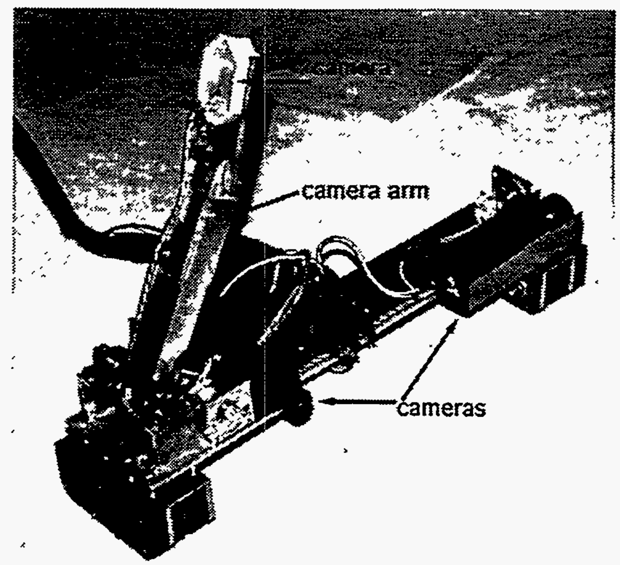

Figure 4. The Camera Crawler. It has three cameras and over 50 watts of lighting.

The Surface Prep Crawler incorporated an industrial 4" grinding motor equipped with a cup brush to provide the cleaning action. The motor was mounted on an air-actuated hinge to provide compliance of the brush with the surface to be cleaned. The hinge was spring-loaded to allow the assembly to fail-safe should the air supply be lost. This attachment has two cameras with lights; one color camera to provide a view of the surface at the point of brush contact and one black and white forward-looking camera for navigation. It is worth noting that the wire brush was rotating away from the camera lens and no particulates accumulated on the lens. Tests were done at one point with air blowing across the lens to prevent debris from sticking, however the opposite occurred. It was concluded that a static charge was induced by the air flow on the lens and caused it to attract dust particles, therefore it was omitted from the final design.

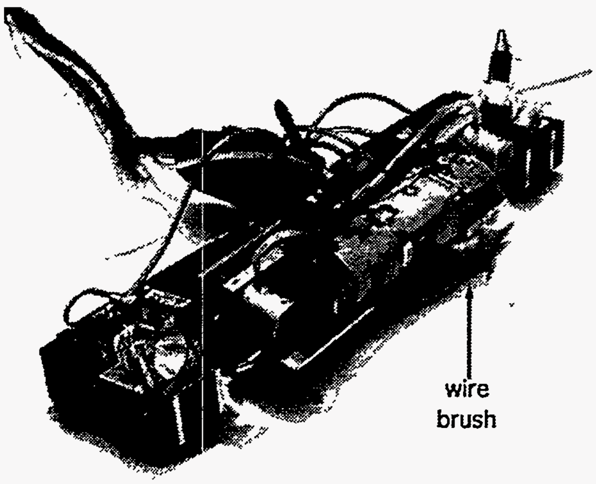

Figure 5. The Surface Prep Crawler. It carries a grinder motor and brush to remove loose scale and debris from the surface.

The system for crawler deployment is a specialized tool with an "umbrella-like" actuation, that in a closed configuration, will fit through a 10" diameter hole. The Deployment Tool has a flat carbon steel plate that provides space for two crawlers. An onboard camera provides a view of the crawlers as they are driven off of or onto the plate.

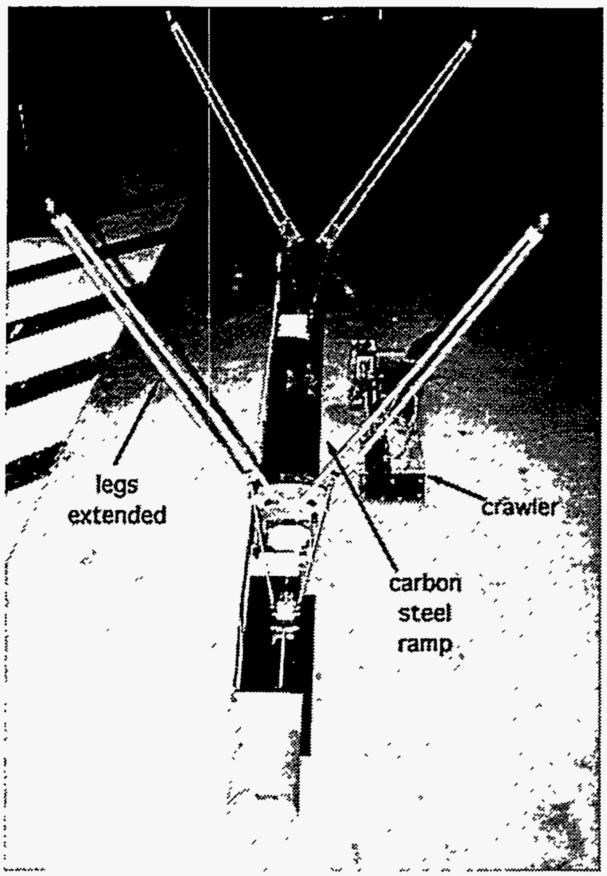

Figure 6. The Deployment Tool. It can load 2 crawlers simultaneously through a 10 inch diameter hole.

The crawlers are positioned on the Deployment Tool at tanktop level. The tool with two crawlers weighs approximately 85 pounds. Once the tool is loaded, the tool is lowered using a winch until it reaches the desired elevation. At that point, the tool is positioned so that the ramp is located on the tank-side and legs are deployed by air cylinders. The extension of the legs keeps the ramp positioned toward the tank surface and forces the ramp against the tank. When properly located on the tank wall, pressure switches are activated to indicate proper contact. The crawlers can then be driven onto the tank wall. Retrieval of the crawlers is accomplished by reversing the procedure. The Deployment Tool can remain on the tank wall during an inspection or can be removed.

A junction box is also provided which is located at ground level close to the inspection port. This box provides a known break point in the event that new control cables should be needed. The junction box allows only the in-tank cables to be replaced rather than the entire length. The junction box also provides the shortest path to introduce ultrasonic couplant and compressed air into the system.

The mobile control trailer (MCT) was originally built to support remote NDE inspections of the WSRC reactor tanks. It is an environmentally controlled trailer that can be located at the tank farm and powered from a standard welding receptacle. It contains all the equipment the operator would need to remotely control all three crawlers, monitors for the eight cameras, UT data acquisition and communications. The audio controls allow all inspection team members to be in voice contact with each other during any operations. The video controls allow any signal from any camera to be displayed on any monitor within the MCT or to be recorded on one of the two video recorders. Signal generators overlay the time and date on all signals to provide chronological information.

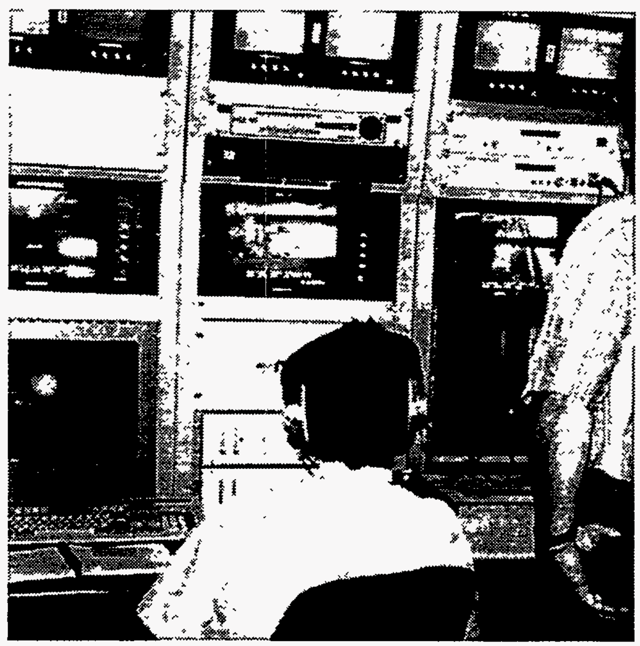

Figure 7. Inside the Mobile Control Trailer.

Component and system testing was an integral part of the project development. Vulnerable components such as the encoders, motors, cameras and other electronic components were radiation tested to failure or to an accumulated dose of 1.5 X 10E6 Rads. The UT Crawler was tested in an environmental chamber at 100% humidity and 175°F for 24 hours to determine resistance to moisture and heat. Additional testing was performed to determine positional repeatability, cleaning efficiency, durability and emergency retrieval. Full scale mock-up demonstrations were conducted at WSRC at various stages of the development phase. The final equipment demonstration was conducted by deploying the UT Crawler onto an underground WSRC waste tank and collecting UT data. Upon completion of this milestone, the equipment was shipped to WVNS for final preparations for the first inspection.

PROGRAM IMPLEMENTATION

The implementation of the WVNS inspection program was a team effort from the beginning that took advantage of the strengths of each site. SRTC took the lead to develop, test, and deliver the equipment while WVNS took the lead to define the scope of the initial inspections and to provide the onsite support for the inspections. During the development phase, additional opportunities for cost-sharing were identified.

Through the DOE technology transfer initiative, a commercial NDE company expressed interest in participating with SRTC in a Cooperative Research And Development Agreement (CRADA). The CRADA provided the project with an opportunity to leverage existing funds so that the ultrasonic acquisition technology could be upgraded, the UT Crawler could be seamlessly integrated to the upgraded UT system, and direct support from the commercial vendor could be obtained.

Also, during the development phase, the WSRC Waste Management Engineering (WME) division worked with SRTC to acquire the delivery system for their use. This involvement resulted in the crawler system being integrated to a second commercial UT acquisition system and also brought additional funding to the project from WME to support the preparations and execution of the final equipment demonstration which used one of the WME underground tanks.

Concurrent with the underground demonstration, SRTC finalized the drawings for the equipment and prepared generic procedures for the operation and trouble-shooting of the equipment and systems as well as a generic ultrasonic procedure and recommendations for system and personnel qualification. All procedures were then transferred to WVNS on electronic media to enable modification of the procedures to meet their specific needs. WVNS then took the lead in project implementation with SRTC providing technical personnel to assist in equipment orientation and maintenance and to help correct "bugs" found during onsite training and startup.

SUMMARY

WVNS took delivery of the inspection equipment September 1994. Mock-ups were used to allow the WVNS and contracted personnel to run the crawler systems and become familiar with their operation. Reference plates were mounted in the mock-up and were automatically scanned by the inspection personnel to qualify the system, procedure, and operators. In early October, 1994, the first deployment of the Camera Crawler was performed on tank 8D-1. After the Camera Crawler was retrieved, the UT Crawler was deployed to take thickness readings around the deployment location. Unexpected surface conditions resulted in limited thickness data. The winter weather conditions inhibited further deployment due to the equipment being deployed through the access ports exposed to the elements. Further data collection was postponed until the Spring of 1995. Evaluations of the collected data are ongoing to determine the next phase of the inspection once it resumes in 1995.

The similar system, developed for Waste Management Engineering at WSRC, was deployed onto Tank-50 November 1994. A strip of the tank wall was mapped with success including both the top and bottom knuckle, covering an area 6 inches wide from top to bottom. The Crawler was retrieved from the tank and a few modifications were made to make the system more user friendly and reliable. The system was again deployed onto the tank to make further thickness maps at different locations. The current schedule has the equipment in use year round making four thickness maps per tank on the numerous tanks in the WSRC tank farm.