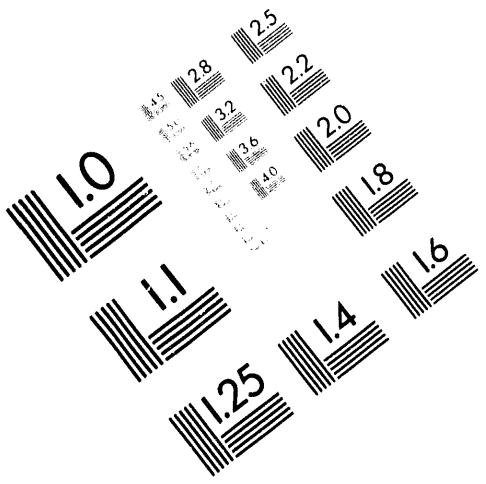

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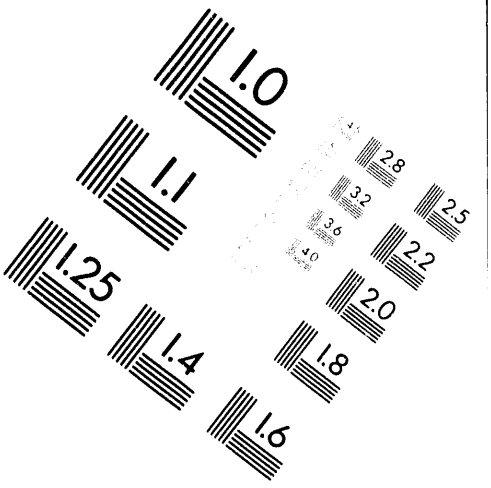

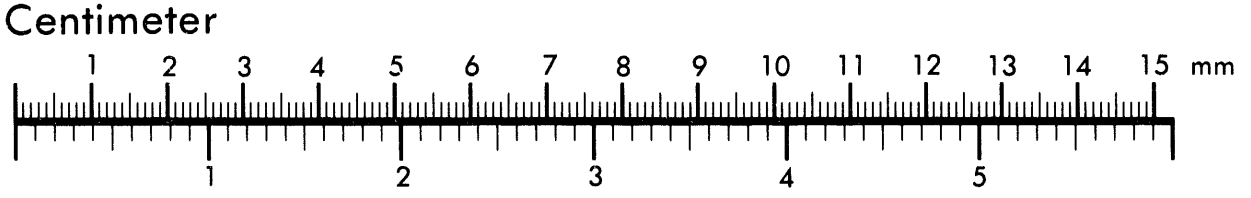

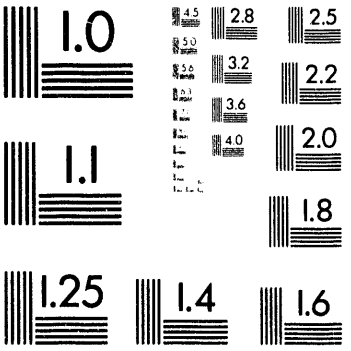

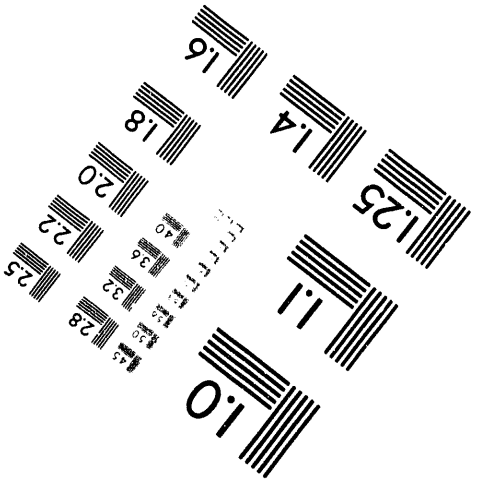

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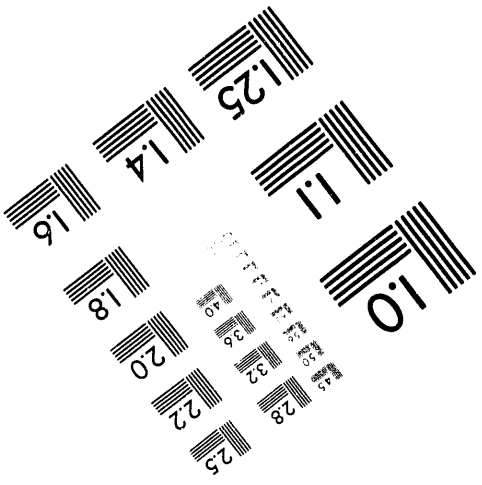

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WSRC-MS-94-0328

WASTE TANK INSPECTION AND CHARACTERIZATION WITH AUTOMATED UT AND ROBOTICS

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DISCLAIMER

WASTE TANK INSPECTION AND CHARACTERIZATION WITH AUTOMATED UT AND ROBOTICS

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ABSTRACT

Equipment and Materials Technology (E&MT of the Westinghouse Savannah River Company) has developed a robotic system to deliver an ultrasonic transducer to the wall of underground storage tanks (USTs). The system is designed to meet the physical and environmental constraints of the USTs and will provide the ability to visually survey the wall, clean the surface and ultrasonically map the wall thickness.

I. INTRODUCTION

Several DOE sites maintain storage vessels for the temporary storage of High-Level Waste (HLW). These vessels are typically made of carbon steel, and have a capacity of roughly one million gallons. Most of the vessels are nearing their originally defined service life and keeping them in operation is a more desirable option when compared to the cost of building replacements. A system is needed to "map" the tank wall thickness so that remaining tank life can be determined.

II. DESIGN

The inspection system is based on a steerable, magnetic wheeled crawler that adheres to a carbon steel tank wall with a 200 lb. holding force. Attachments are bolted to the "basic" crawler to deliver cameras for visual surveillance, wire brush for surface cleaning and an ultrasonic scanning head for thickness mapping. The crawlers have the capacity to incorporate one or more of these functions.

The crawler itself consists of two independent drive modules connected together by a "compliance" plate. Each drive module has two magnetic wheels directly driven by a DC gear motor. The wheels are commercially available rollers which are normally used in the steel mill industry for handling carbon steel sheets. These rollers have a 50 lb. holding force and are directly applicable as wheels for the crawler. The compliance plate is a 12 gage stainless steel plate that flexes to allow the two drive modules to move independent of each other. This independent motion is very critical to ensure one drive module does not de-couple from the wall as the other module drives over a weld seam on the tank wall.

Steering and turning of the crawler is achieved by the independent control of each drive module which makes use of "skid steering". The steering is the same as in treaded vehicles such as bull-dozers. The total holding force of the crawler on the tank wall is 200 lbs. This is not, however, the load capacity of the crawler in a vertical orientation, the actual capacity is 50 lbs. Loads heavier than 50 lbs. on the crawler will cause the wheels to slip on the tank surface.

This slippage does not indicate the crawler will fall off of the wall, rather it means it will slide down the tank wall.

The crawler is designed to survive the severe environmental conditions in the tanks. All components on the crawler have been selected and tested to withstand corrosive materials, radiation effects, humidity, and a wide temperature range. All inspection equipment is designed to be decontaminated or easily decommissioned when removed from the tank area. A typical inspection will consist of a Ultrasonic Testing (UT) crawler, a Camera crawler, a Surface Preparation crawler, a Deployment Tool and a Mobile Control Trailer (Figure 1).

A. UT Crawler

The basic crawler is fitted with the UT attachment for delivery of the transducer. The attachment consists of a direct drive motor connected to a ball screw shaft, which moves a spring loaded gimbal fixture along its axis. The transducer, mounted on the gimbal, is capable of 10 inches of contact over the area to be inspected. There is a stow position at the end of the ball screw to remove the transducer head from the tank surface. Scan speeds up to four inches/second can be achieved with the direct drive ball screw mechanism. The UT crawler has a camera to view the transducer and inspection area during a scan.

B. Camera Crawler

The Camera Crawler consists of a basic crawler with an attachment containing all the components for the visual surveying. The attachment has two moving booms that can reach approximately 18 inches above the surface of the tank. The camera mounted to the boom gives the operator a bird's eye view of the inspection in progress. The attachment also contains a radiation hardened camera that tracks the movements of the UT crawler. The Camera Crawler will also be used to obtain visual surveys of the tank's surface condition.

C. Surface Preparation Crawler

The purpose of the surface preparation is to prepare the external surface of the tank for the UT inspection. For many USTs, a method of rust and scale removal is required to obtain accurate ultrasonic readings on the external surface of the tank. The Surface Preparation Crawler uses two air cylinders to deploy a grinder and attached brush to the surface of the wall. The activation of this tool is accomplished by energizing the solenoids which release a spring loaded grinder to the surface. Also located on this crawler are two cameras, one dedicated to driving the crawler and the second looking at the surface of the tank and at the cleaning brush. The grinder will clean a swath of approximately 2 inches per pass.

D. Deployment Tool

The crawlers are inserted and removed from the tank annulus with a specialized Deployment Tool that is lowered down through a ten inch diameter access riser with an electric winch and overhead gantry crane. The tool is approximately 8 feet long and 9 inches in diameter. The body of the device is constructed of carbon steel, which allows the magnetic wheels of the crawler to adhere to the tool. The tool weighs approximately 30 lbs. unloaded, and 100 lbs. fully loaded with two crawlers. Once the tool is lowered to the desired depth, air cylinders are actuated deploying legs which push out on the concrete vault moving the crawler ramp flush with the surface of the tank. Once the Deployment Tool is flush with the surface of the tank, the crawlers can be driven off the tool and onto the tank wall. The crawlers are driven off the Deployment Tool and maneuvered up to 50 feet around the tank to perform the necessary tasks. Onboard cameras and lights allow the operator to observe the progress of deployment. Both the

crawlers and respective cables are independent of the tool, making it possible to remove the tool anytime during the inspection. The Deployment Tool also utilizes an on board radiation tolerant camera that will provide the needed visuals for insertion and removal of the crawlers as well as the movements on and off the deployment ramp. This camera will aid the operators with cable management of the crawlers as they move. To remove the crawlers, they are driven back onto the Deployment Tool and the tool is winched out of the access port.

E. Mobile Control Trailer

The mobile control trailer (MCT) is an environmentally controlled work area for performing the waste tank inspection. The trailer is approximately 50' long, 13' tall and 10' wide. Inside the trailer are three video consoles and a crawler control center. The crawler control center consists of two computers and monitors, three control chassis, a communication station and nine video monitors. One of the computers controls the camera crawler and surface preparation crawler. The other computer controls the UT crawler and processes UT data. The three control chassis contain the joystick controls, lighting controls and amplifiers for the crawler motors. The communication station provides two-way communication between the operator(s) and the personnel in charge of cable management and equipment retrieval at the tank top. The nine video monitors are available for displaying views from the crawlers' on-board cameras and the deployment tool camera. The operators at the crawler control center can switch the video from any of the nine monitors to the three video consoles for viewing by personnel not performing the inspection.

A PC-AT 486 computer system monitors, records, controls and displays the movement of the crawler as it progresses along the tank wall. The computer employs a DC servo motion controller board to drive the crawler motors using magnetic encoder feedback. By dedicating a dc motor and encoder to each pair of wheels, the crawlers can drive forward, reverse, spin clockwise or counterclockwise using either the mouse controls or a joystick. The computer system and crawler can be separated by 250 feet of cable to perform remote inspections. The drive software provides a mouse driven graphical interface for the control of the crawler. The software is commercially available and open-ended to allow for task specific computer control (e.g. switching on/off lights or the couplant pump).

The positioning system developed for the crawlers uses horizontal and vertical weld seams for tank coordinate references. Encoder feedback and inclinometers provide relative position indication. A camera crawler with a radiation-hardened scoping camera tracks the UT crawler during a scan and verifies that it does not drift vertically.

III. APPLICATION

A. West Valley Nuclear Services

One application for the crawler inspection system is the West Valley Demonstration Project HLW Storage Tanks Integrity Maintenance Program Nondestructive Examination of Tanks 8D-1 and 8D-2. West Valley Nuclear Services Company (a subsidiary of Westinghouse Electric Corporation) was awarded a DOE contract to solidify HLW into a form suitable for transportation to and eventual disposal in a federal repository. The HLW, consisting of a precipitated sludge and an alkaline supernatant, is presently contained in two HLW underground storage tanks.

The inspection of the primary liner of the WVNS tanks will be done from the exterior side in the annular space formed between the tank wall and the concrete vault. The inspection will consist of visually surveying 100% of the tank surface, cleaning the surface where necessary, and ultrasonically mapping the wall thickness in three separate locations. Access to the annular space is limited to two 10 inch diameter access ports located approximately 180° apart. The radiation rate at the periphery of the tanks is approximately 1000 R/hr, precluding any attempt at a manual inspection. The temperature can vary from 80 to 175 °F and the humidity level is saturated vapor.

The ultrasonic system is an AmData, Intraspect/PC (I/PC) Ultrasonic Imaging System. This system includes a computer, external storage media, a color printer and the UT crawler. The I/PC uses an IBM compatible computer with a PC-DOS operating system. The UT system provides a real-time digitized time-of-flight (TOF) representation of the wall thickness. This information is available for immediate use to re-interrogate a problem area or can be archived on optical disk.

B. Savannah River Site

A second application for the crawler inspection system is the Savannah River Site (SRS) High Level Waste Tank Inspection. At SRS, six HLW underground storage tanks will be inspected with the crawler system. The inspection will consist of ultrasonically mapping the wall thickness of four 10 inch wide vertical strips per tank. No surface preparation is anticipated. Access to the annular space is limited to fourteen 8 inch diameter access ports. Four of these ports, located approximately 90° apart will be used to deploy the crawlers. The Deployment Tool has been modified to allow insertion into the smaller 8 inch riser. The radiation rate at the periphery of the tanks is approximately 500 R/hr.

The Projection image Scanning Ultrasonic Inspection System (P-SCAN) will be used to perform the inspection. The system has three major components; a PSP-3 processor, a computer crawler controller and a crawler. The UT system provides a real-time digitized time-of-flight (TOF) representation of the wall thickness. This information is available for immediate use to re-interrogate a problem area or can be archived on disk. The computer controller is responsible or positioning the crawler at the inspection location and sending the PSP-3 processor position information during a scan. The SRS system is designed to fit in two, easily portable, 4 feet high by 20 inches deep, standard 19 inch rack mount cabinets. The cabinets will contain the computer controller and monitor, four video monitors, a control chassis and the PSP-3 processor.

ACKNOWLEDGMENTS

The development of the crawler waste tank inspection system was funded by the West Valley Nuclear Services Company and the Westinghouse Savannah River Company.

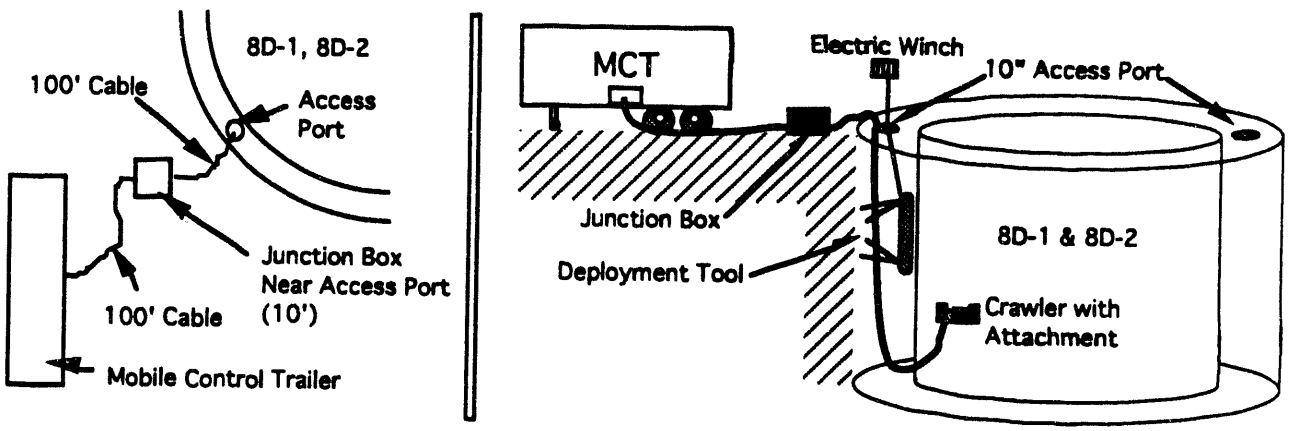

Figure 1 E&MT Waste Tank Inspection System

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