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Deployment Plan for Small Roving Annulus Inspection Vehicle

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1. Executive Summary

The Small Roving Annulus Inspection Vehicle (SRAIV) is a modified commercially available wall crawler designed to supplement the In-Service Inspection (ISI) of Savannah River Site (SRS) Waste tanks. The SRAIV provides an improved capability to achieve a more complete inspection of the tank walls than existing methods. The SRAIV will be deployed through annulus risers in the tank to gain access to tank walls requiring inspection. The SRAIV will be deployed using a manually operated deployment pole and will be coupled to the wall using permanent magnet wheels. Navigation will be performed from the remote console where pictorial views can be displayed from the on-board cameras. The unit will incorporate multiple UT transducers for traditional weld examination. In addition, a specially developed Tandem Synthetic Aperture Focusing Technique (TSAFT) UT scanning bridge can be attached to provide further investigation of the knuckle region while the vehicle remains on the vertical surface of the tank wall. In summary, the SRAIV will provide features that enhance and expand the capability of the SRS ISI program.

Acronym List

ALARA	As Low As Reasonably Achievable
DOE	Department of Energy
DST	Double Shell Waste Tank
F&R	Functions and Requirements
NDE	Non-destructive Examination
PDT	Performance Demonstration Test
PNNL	Pacific Northwest National Laboratory
R/hr	Roentgen/hour
SAFT	Synthetic Aperture Focusing Technique
SRS	Savannah River Site
SST	Single-Shell Waste Tank
TFA	Tanks Focus Area
TSAFT	Tandem Synthetic Aperture Focusing Technique
TTP	Task Technical Plan
UT	Ultrasonic Testing

WSRC	Westinghouse Savannah River Company

3. Background

SRS has 47 tanks that are used to store waste from processing nuclear material including plutonium and uranium since the 1950's. The tanks are located underground, fabricated from carbon steel and include multiple containment barriers to prevent leakage. The oldest tanks were built between 1951 and 1953. Type I, II and III tanks are double containment tanks with an annulus space between the primary carbon steel tank wall and the secondary containment. The SRAIV is designed for inspecting tanks through annulus risers which provide access to the tank walls. The SRAIV is planned to be used for inspecting Type III tanks. There are 27 Type III tanks that the SRAIV may be used to inspect. The Type III tanks also have a carbon steel secondry liner. The original design life of some of the SRS tanks and transfer systems has been exceded, however, they need to remain in service in order to process the waste. There are no plans to build additional tanks so it is essential to continue to validate the integrity of existing tanks and transfer systems. Life management of these tanks includes an on-going surveillance program where the primary and secondary tank walls and bottom knuckle areas in the annulus space are viewed with a manually manipulated camera. These visual surveillances are performed on all accessible surfaces in the annulus in a systematic manner. NDE inspections of the primary tank wall and bottom knuckle areas in the annulus space have been accomplished using equipment introduced into the annulus space through existing tank pipe risers. Remotely controlled magnetic wall crawlers equipped with cameras and ultrasonic transducers integrated with commercially available "P-scan" data analysis equipment have been used to visually and ultrasonically inspect (UT) tank walls, weld areas and leak sites. PNNL at Hanford developed a UT method identified as TSAFT utilizing twin probes to ultrasonically examine below the knuckle region while remaining on the vertical wall surface.

Visual inspection is conducted on the primary wall of the 27 type III tanks at a 100% coverage rate. Existing UT equipment provides for limited access of the knuckle region due to inability to traverse the curved knuckle surface of the tank wall. Travel distance of wall crawlers is limited due to crawler payload vs. tethered cable weight, limited crawler ground clearance, and inability to traverse the curved knuckle region. Newer technology that incorporates stronger magnetic coupling force, higher ground clearance, and the ability to utilize existing UT technology and the newly developed TSAFT UT method is expected to enhance the inspection capabilities at SRS.

4. Hot Deployment Strategy

The strategy for deploying the SRAIV in actual waste tanks is to continue with the same technique that has worked in the past. Similar vehicles have been successfully inserted through tank annulus riser openings and performed inspections. This vehicle has some advantages such as greater clearance and a higher payload that should prove beneficial while navigating over welds in future inspections. Deployment of the SRAIV with the TSAFT attached will require a portable tripod style hoist with a power winch due to the extra length and weight when the combined system is used for knuckle inspections. Prior to inserting the SRAIV alone or with the TSAFT attached the vehicle should be prepared to facilitate decontamination. This may involve wrapping portions in plastic or tape so the vehicle remains as clean as possible after protective coverings are removed following an inspection.

The vehicle selected for the SRAIV is a Force Institute Model AMS-1TM. A motor drive unit MDU-13 and a pneumatic control, PCU-7 are used to control the vehicle. A picture is shown below. The SRAIV will also be outfitted with inspection equipment including P-Scan UT transducers and SAFT/TSAFT transducers. The vehicle will be equipped with two video cameras for visual inspection: one color camera and one high-resolution black and white camera. A more detailed description of the requirements for the equipment is available in reference 1.

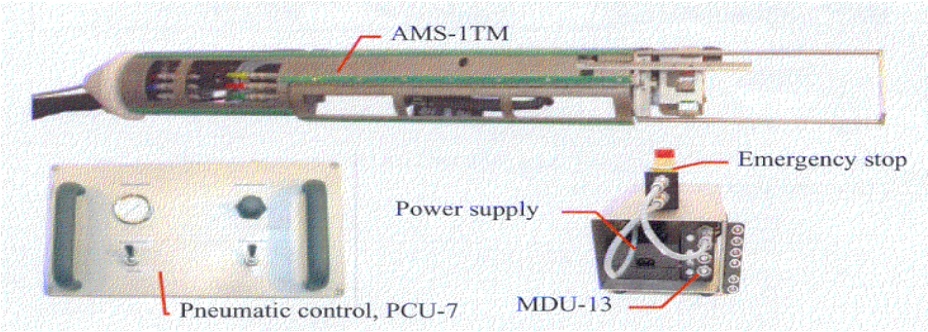

Figure 1 - SRAIV

Prior to deployment in radioactive service the operation of the SRAIV will be demonstrated in a clean mockup facility. The SRAIV along with the TSAFT measurement head shall be qualified in two areas prior to deployment in an SRS waste tank. The first qualification involves successful tank entry and removal via a 5-inch riser and successful navigation to the knuckle while on the tank surface. (A 5-inch riser is the smallest required entry point.) This activity along with other qualification tests is described in reference 6.6, "Performance Demonstration Test Plan for the Small Roving Annulus Inspection Vehicle." The second qualification involves meeting UT specifications outlined in section 4.3.3 of reference 6.3. Both the navigational and UT qualifications will be performed using a mockup located at SRS in Building 723-A. This mockup has a variable diameter riser, a vertical wall section and a knuckle region of representative thickness and materials of construction. Known flaws representing pitting and cracks will be placed below the knuckle. The SRAIV will be required to detect these flaws per the requirements in reference 6.3. After completing the activities required in the test plan the vehicle will be ready for active inspection service.

The generic steps required to deploy the vehicle in a radioactive tank include:

- Staging the SRAIV and all necessary support equipment on the tank top.
- Remove the selected plug from the target riser.
- Lower the SRAIV into the riser using the manual deployment pole.
- Couple the vehicle to the tank wall targeted for inspection.
- Perform inspection using vehicle navigation system in conjunction with the P-Scan UT data collection system and video recording capabilities.
- Return SRAIV to a position below the riser in preparation for removal.
- De-couple the vehicle from the tank wall using the built-in jacking system.
- Recover the SRAIV by retracting the cable tether.
- Replace the riser plug.

Inspection methods, equipment qualifications and inspector qualifications are described in reference 6.3. The initial deployment of the SRAIV, which will demonstrate the capabilities of this new generation wall crawler and associated UT inspection system, is expected to be in FY03.

5. Conclusion

The SRAIV equipped with UT probes and the newly developed TSAFT UT system will enhance the ability to inspect SRS tanks including the knuckle region in order to provide a basis for tank life management. Stronger magnetic wheels incorporated on the SRAIV allow full access to tank walls for inspection. The wall crawler will be deployed through risers in the annulus section of tanks requiring inspection. There can be very high confidence that the SRAIV can be deployed successfully on tank walls and provide useful inspection data since the same operation was performed with earlier generation vehicles.

6. References

1. Wong, J. W., WSRC, Dyches, G.M., WSRC, Pardini, A. F., WSRC, *Functions and Requirements for the Small Roving Annulus Inspection Vehicle (U)*. WSRC-MS-2001-00557, Savannah River Site, Aiken, SC 29808 (6/28/01).
2. Wong, J. W., WSRC, Dyches, G.M., WSRC, Pardini, A. F., WSRC, *Development and Procurement Strategy for the Small Roving Annulus Inspection Vehicle (U)*. WSRC-MS-2001-00558, Savannah River Site, Aiken, SC 29808 (6/28/01).
3. Wiersma, B. J., et al, *In-Service Inspection Program for High Level Waste Tanks(U).* WSRC-TR-2002-00061 Revision 1, Savannah River Site, Aiken, SC 29808 (7/02).
4. Pardini, A.F., et al, *Conceptual Design of the Small Roving Annulus Inspection Vehicle SAFT/TSAFT System for SRS DST Knuckle Inspection (U).* PNNL-40924-SRAIVCDR-001, Pacific Northwest National Laboratory, Richland, Washington 99352 (9/28/01).
5. Pardini, A.F., et al, *R Final Design Package from the Small Roving Annulus Inspection Vehicle - SAFT System (U)*. SRAIV-SAFT-40924-FDR, Revision 0, Pacific Northwest National Laboratory, Richland, Washington 99352 (3/01).
6. Dyches, G. M., WSRC, *Performance Demonstration Test Plan For the Small Roving Annulus Inspection Vehicle (U).* WSRC-MS-2002-00744, Savannah River Site, Aiken, SC 29803 (8/29/02).

7. Appendix

7.1 SRAIV Images

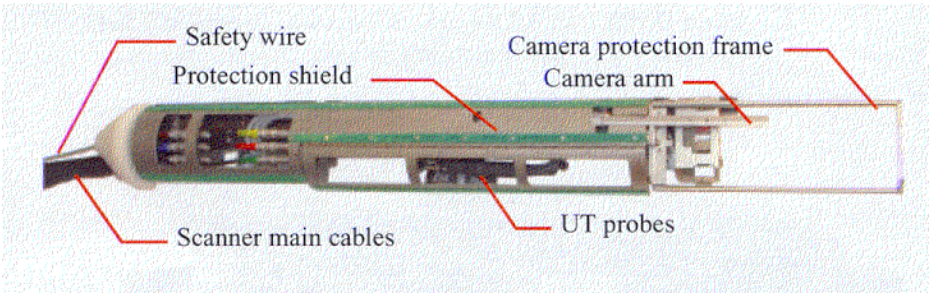

Figure 2 – SRAIV Top View

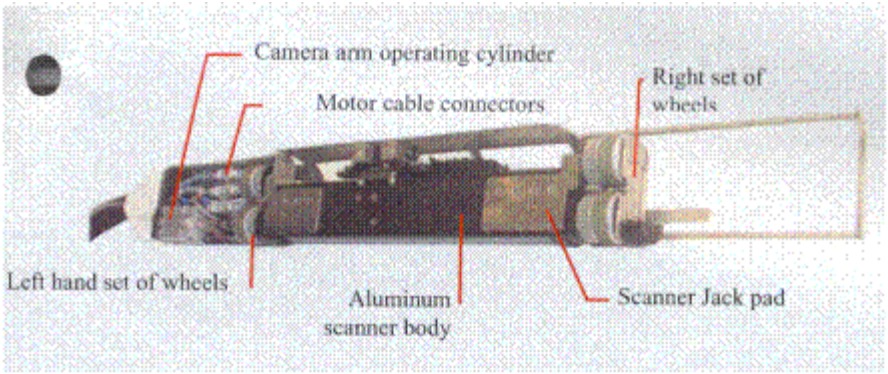

Figure 3 – SRAIV Bottom View

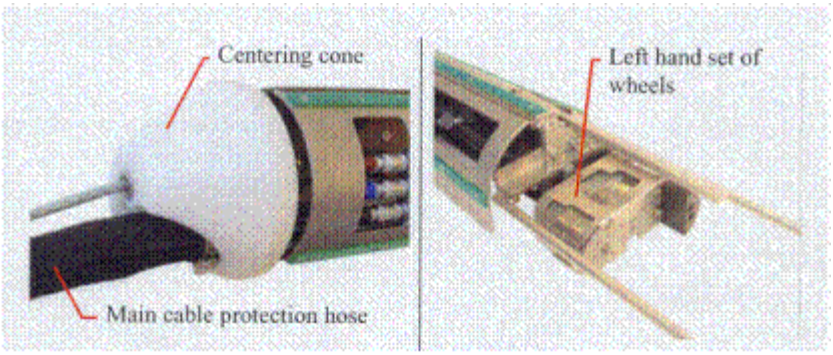

Figure 4 – SRAIV End Views

7.2 TSAFT Figures

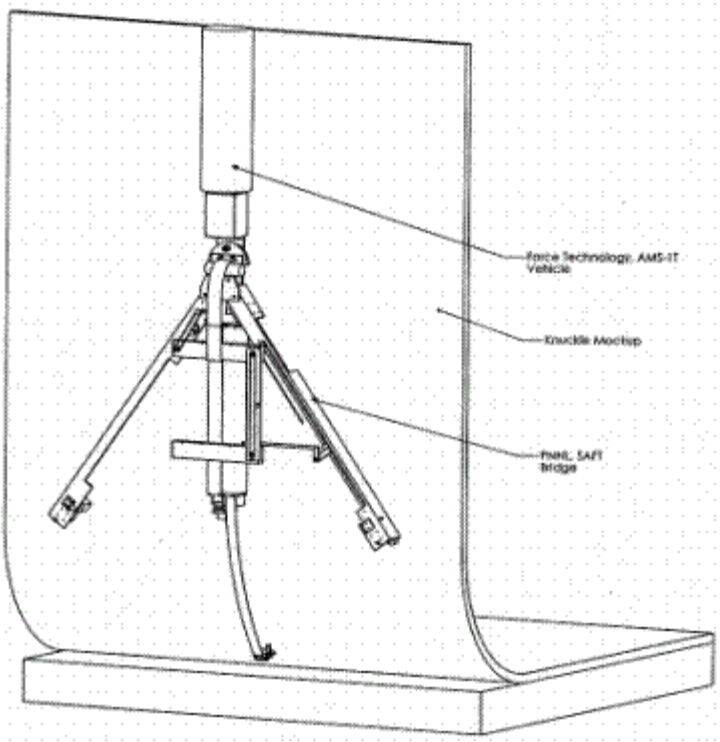

Figure 5 – TSAFT Deployed on Tank Wall

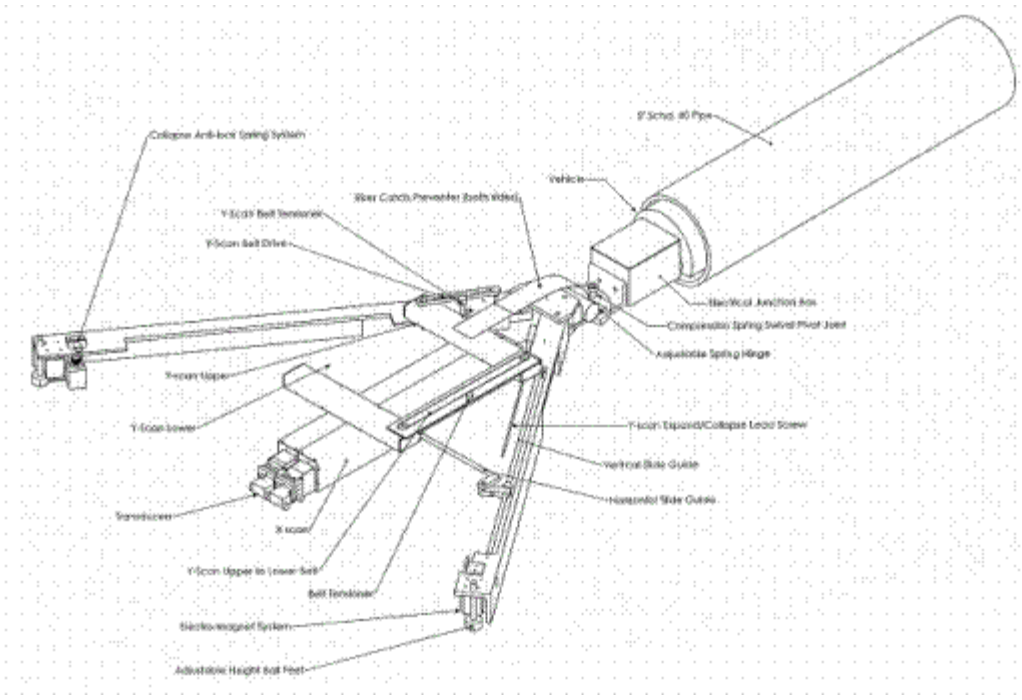

Figure 6 – TSAFT Illustration

7.3 Tank Design and Construction

This section summarizes pertinent information on the Type III High Level Waste Tanks.

Type III Tanks

Type III Tanks (See Figure 7)

Constructed – 1967 through 1972
Capacity – 1,300,000 gallons
Material – ASTM A516, Grade 70 Carbon Steel
Construction Code – ASME-56
Project Numbers – 9S1232 and 9S0974
Six Tanks total. H-Area Tanks 29-32. F-Area Tanks 33-34
Single wall secondary liner. Material is ASTM A516 Grade 70 carbon steel

Type IIIA Tanks (See Figure 7)

Constructed – 1974 through 1981
Capacity – 1,300,000 gallons
Material – ASTM A516, Grade 70 Normalized (Tanks 25-28, 35-37) and ASTM A537, Class I (Tanks 38-51) Carbon Steel
Construction Code – ASME-56
Project Numbers – 9S1463, 9S1493, 9S1618, 9S1747, 9S1828
21 Tanks total. H-Area Tanks 35-43 and 48-51. F-Area Tanks 25-28 and 44-47.
Single wall secondary liner. Material is ASTM A516 Grade 70 carbon steel

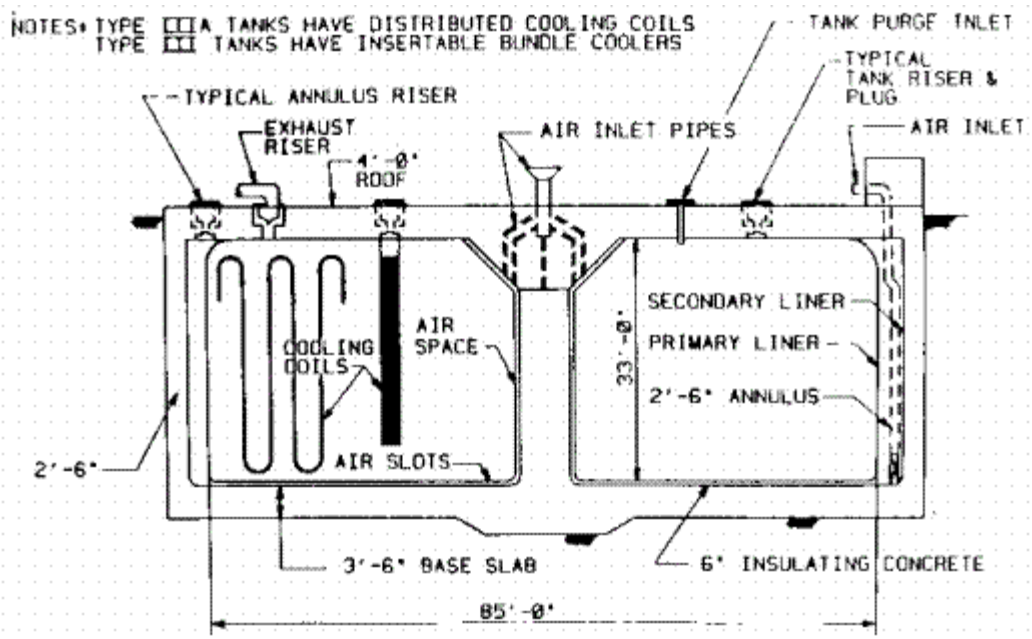

Figure 7 - Type III High Level Waste Tank