STARTUP square ROBOT

HOST TVA

Benefits of Submersible Robotic Tank Inspections for Power Plants

TECHNOLOGY SOLUTION

Utility companies have a longstanding commitment to enhancing the safety, efficiency, and affordability of their operations. While inspections of above-ground storage tanks are infrequent, they're a mandated necessity. Traditionally, these inspections involved taking tanks out-of-service (OOS), entailing costs for product removal, tank cleaning, the inspection process, and refilling. This lengthy process exposes personnel to hazardous, confined spaces and contributes to CO2 emissions.

Square Robot offers a transformative solution for utilities through its submersible, autonomous inspection robot. This innovation conducts inspections while tanks remain in operation, even actively flowing, and employs proprietary navigation and advanced phased array ultrasonic testing (PAUT) to meticulously examine tank bottoms. Square Robot can identify corrosion on the tank bottom on both product and soil sides with remarkable accuracy - within six inches - while also measuring coatings and fiberglass linings. Additionally, the robot systematically tracks settlement patterns of the tank bottom, providing valuable insights into structural integrity combined with high resolution visuals.

By adopting this robotic solution, utilities can protect their workforce from hazardous environments, reduce emissions, and ensure the continuous operation of valuable assets, eliminating the need for costly out-of-service inspections. Square Robot's innovative technology represents a significant step in enhancing the efficiency, safety, and cost-effectiveness of utility operations.

PROJECT OVERVIEW

Tennessee Valley Authority wanted to evaluate Square Robot's capabilities to provide insights into TVA's above ground storage tanks while aligning with its commitment to safety. Square Robot had the opportunity to showcase its technology by performing in-service robotic inspections on four of TVA's above ground storage tanks at two separate facilities. The goals for this project included:

- Evaluate Square Robot's inspection capabilities in different products - both fuel oil and water
- Evaluate Square Robot's performance in a challenging tank environment by inspecting a bolted tank bottom with the tank flowing.
- Compare the tank bottom inspection coverage and data collection to both OOS and other robotic inspection methods.

- Quantify the impact on TVA's safety initiatives and emission control.
- Compare costs, length of time and project management hours of OOS inspections to Square Robot's robotic inspection.

RESULTS & LEARNING

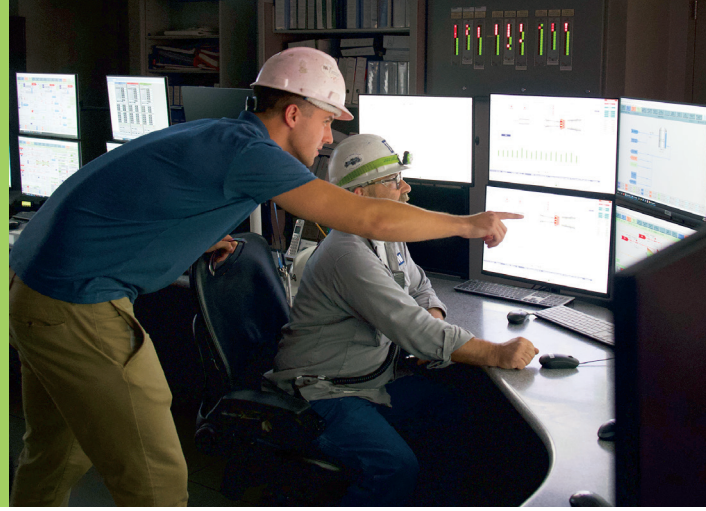
Square Robot conducted robotic inspections on three fuel oil tanks at TVA's Marshall Combustion Turbine plant, and one firewater tank at the Magnolia Combined Cycle plant, delivering impressive results and substantial benefits for both facilities.

The identical fuel oil tanks at the Marshall plant were 62' diameter, holding about 1,000,000 gallons of fuel. Square Robot's inspection resulted in:

- Inspection of all 3 tanks in 3.5 days, compared to the OOS inspection which would take weeks to a month per tank.

The Square Robot demonstration showed TVA how the plant can maintain ongoing operations while the storage tank inspections were in process. This could change how we think about doing tank inspections going forward.

James Linder, TVA,
TVA Technology Scout



- Tank bottom coverage around 60% and data collection averaging 100 GB per tank, employing the 256 element PAUT. Prior OOS inspection collected 28 single element UT readings across the tank bottom.
- Containing an estimated 6 tons of CO2 emissions (total) by eliminating the need to vent and drain the tanks.
- Eliminating an estimated 850 confined space entry hours needed for the OOS inspections. Additionally, eliminating the need for TVA to have dedicated personnel overseeing the confined space entry.
- TVA plant personnel also indicated that the Square Robot inspection not only saved thousands of project management hours but also eliminated the need to transport fuel in and out. The OOS inspection would have required approximately 130 trucks per tank to remove fuel, potentially leading to a loss of half a day of power plant operations should the fuel have been needed during the OOS inspection period.

Moving to the Magnolia Combined Cycle plant, Square Robot tackled a challenging inspection of the 92' firewater tank that supported ongoing plant operations. Despite its complexity, which included flows up to 5500 GPM, a bolted tank

Tank Inspection	In-tank Time	Coverage	Obstacles	Data Retrieved	API 653 Report/ Delivery	Confined Space Hours (estimated)	CO2 Emissions (estimated)
TVA Marshall Tank 4 7/10/23	4 hours 58 min	61% of tank bottom	Floating suction, center column, 2 steam lines & sump	98.9GB	July 31 - 20 yr inspection interval	286 confined space entry hours for OOS	1.96 tCO2e
TVA Marshall Tank 3 7/11/2023	4 hours 50 min	60% of tank bottom	Floating suction, center column, 2 steam lines & sump	109.8GB	Aug 11 - 20 yr inspection interval	286 confined space entry hours for OOS	1.96 tCO2e
TVA Marshall Tank 2 7/12-7/13/2023	5 hours 54 min	56% of tank bottom	Floating suction, center column, 2 steam lines & sump	91.4GB	Aug 11 -20 yr inspection interval	286 confined space entry hours for OOS	1.96 tCO2e
TVA Magnolia Firewater Tank 8/14-8/17/2023	13 hours 24 minutes	10% of tank bottom	Tank bottom bolts, sediment build up, active flow monitoring	126.4 GB	Sept 15 – 5.47 yr inspection interval	544 confined space entry hours for OOS	N/A – water tank

floor and sediment build up, Square Robot achieved impressive results:

- Square Robot's submersible robot was compared against the previous robotic crawler inspection. Previous inspection employed a 63 element spot UT payload which could only access a singular plate of the tank floor, due to the bolts restricting coverage. Square Robot collected over 10x the data, with tank bottom coverage around 10%, touching an estimated 90+ plates and completing inspection in about 3 days.
- Square Robot effectively worked with the plant team to manage flow rates during inspection, aiming to keep the flow at 2500 GPM and below. With the discovery of significant sediment build up, Square Robot combined its data with an extreme value analysis to further increase the insight into the tank bottom condition.
- An estimated 500 confined space entry hours would have been needed for an out-of-service inspection.

TVA received API 653 inspection reports for the tanks, with delivery ranging from 2-4 weeks. The three Marshall tanks had inspection intervals of 20 years, while the firewater tank (due to decreased coverage and lowest remaining thickness levels) had an interval extension of 5.47 years.

> Partnering with TVA for the Incubatenergy Labs cohort program provided Square Robot the opportunity to bridge the gap from the energy industry to the power industry, and showcase the technology and benefits of in-service, robotics tank inspections.
>
> **David Lamont, CEO, Square Robot**

IMPLICATIONS & NEXT STEPS

By utilizing Square Robot's robotic inspection system, utilities can save hundreds of thousands of dollars, ensure the safety of their environment and community, keep operations interrupted, and prioritize outages around the more crucial components of the plant. With this demonstration, Square Robot has proven its ability to not only inspect in flowing, operational tanks, but also use robotic technology to collect more robust data and insights without risking the safety of human life.

To date, Square Robot has inspected over 160 tanks in eight countries and multiple industries, eliminating over 65,000 confined space entry hours and containing the release of around 265,000 lbs of emissions. As Square Robot introduces its technology to the power industry, the company wants to expand its inspection footprint from fossil fuel and coal plants to nuclear plants and is participating in active discussions with the nuclear industry. Square Robot's technology heralds a new era of tank inspections, marked by enhanced safety and remarkable cost-effectiveness.

RESOURCES

SAMUEL JOHNSON
Team Lead, Sr • Plant Support
sjohnson@epri.com

STEPHANIE NOLAN
Business Development
(832) 591-6046 • squarerobot.com
snolan@squarerobot.com

JAMES LINDER
Innovation Scouting
Tennessee Valley Authority
jlinder@tva.gov

INCUBATENERGY LABS

RESOURCES

DAN KILLOREN, PH.D.
Program Manager
Global Innovation Hub
dankilloren@epri.com

JERRY LIGRANI
Program Lead
Incubatenergy® Labs
jligrani@epri.com

labs.incubatenergy.org

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EPRI
3420 Hillview Avenue, Palo Alto, California 94304-1338 • PO Box 10412, Palo Alto, California 94303-0813 USA
800.313.3774 • 650.855.2121 • www.epri.com