



Have you saved 70% for tank cleaning, inspection and repair costs by using robotics?

All tank owners have performed inspections that have negative effects on staff, the environment and their operational efficiencies due to a lack of inspection alternatives. Tank operators have been searching for ways to satisfy API 653 while reducing costs, safety hazards, and environmental risks associated with tank cleaning, inspection and repair. The use of emerging robotic technology for tank inspection is now delivering lower costs, mitigating safety issues and eliminating environmental impacts.

In response to several large tank failures and the introduction of API 653 guidelines governing tank inspection, tank owners have been aggressively cleaning, inspecting and repairing tanks to prevent similar mishaps. New vigorous actions to inspect tanks have lowered the incident of leaking tanks but compliance efforts have had cost, safety and environmental impacts for operators. Most operators have been trying to reduce the impact by focusing on obvious direct costs, and developing rigorous safety procedures. Industry leaders are now considering more challenging opportunities like reducing hidden indirect costs and implementing inherently safer end-to-end processes.

The conventional method for inspecting tanks requires an operator to completely free the tank of product and vapor. Product is drained first through fixed lines and then temporary lines to remove most of the volume. Squeegees and water are frequently used to remove residual product. Finally, fans are used, sometimes in conjunction with vapor recovery/burning equipment to remove tank vapors. Once the tank is certified as vapor free, the tank floor is prepared for inspection, often by sand blasting, and a variety of inspection techniques are utilized including magnetic flux exclusion (MFE) and contact ultrasound (UT). Repairs are made if required, the tank man ways are resealed, and the tank is returned to service. The entire process takes one week to six months depending on the tank size, coordination of contractor schedules, and scope of repairs.

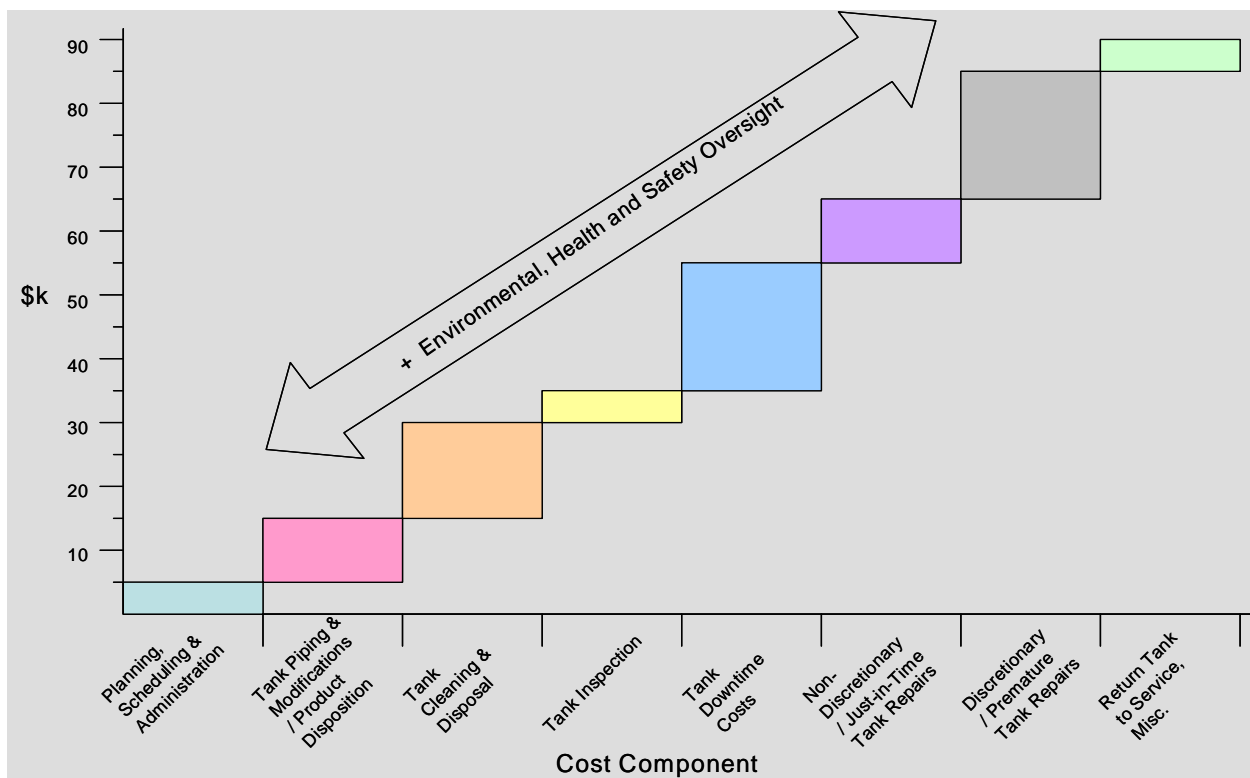
The conventional method presents serious safety and environmental challenges. Product is generally transferred through temporary lines creating an increased risk for spills, contact with personnel and other catastrophes. The tank is opened to the environment via the man way exposing the environment and personnel to substantial vapor releases. This method is a significant contributor to VOC emissions, jeopardizing environmental credits in many jurisdictions. Finally, personnel must make a confined space entry in the tank to perform an inspection. Rigorous enforcement of safety procedures have made the job safer, but even with the best management oversight, the process still results in frequent safety, health and environment incidents. The out-of-service method has both visible and hidden costs that are challenging to control. The visible costs are those payments made directly to contractors for cleaning, inspecting, waste disposal and repair. Unfortunately these direct expenses are usually dwarfed by the indirect, hidden costs. The traditional method involves extensive planning by the operator and multiple contractors before the job is ever scheduled. The planning process typically requires a significant amount of time from internal resources including engineering,

TECHNICAL TOOLBOXES

supply, scheduling, safety, and tank operations. The process for product and vapor freeing the tank also has hidden costs. Frequently owners incur costs for transferring and downgrading product in preparation for cleaning. Sometimes temporary lines are constructed and product must be moved out of the target tank using various systems. Disposition of the tank heel often results in hidden costs because saleable product intermingled with water and sludge is unavoidably given away. Once the tank is down and out of service, the operator incurs supply related costs associated with tank downtime: higher shipping costs for smaller inbound lots, transportation costs for two porting ships or rerouting trucks, and production impacts due to reduced storage capacity. Finally, if repairs are required, more hidden costs occur. The repairs become emergency and unplanned repairs since the operator is eager to return the tank to service. Frequently there is insufficient time to follow a normal bidding and contractor selection process. Instead, the first qualified contractor who can begin work immediately wins the work, completing the repairs typically at a higher cost due to the scheduling imperative. Additionally, repair creep sets in since many repairs are done earlier than warranted just so they can be completed while the tank is out of service, forcing the operator to accelerate deferrable costs into the current budget cycle.

At most companies the full cost of tank cleaning and inspection spans multiple cost centers and there is no one person who accounts for all of the costs associated with the entire process for even one tank. As an example, the engineers know the costs for inspecting the tank but only the traders know the costs for securing an alternative source of product. Another example is that the operator is aware of the incremental trucking costs that are incurred while the tank is down but only the engineer knows the true incremental cost for emergency versus competitively bid tank repairs. Figure 1 depicts the total system cost associated with the tank cleaning, inspection and repair process.

Figure 1: System Cost for Tank Cleaning, Inspection and Repair



TECHNICAL TOOLBOXES

Personnel

Internal

- Facility Operations
- Headquarters, Supply, Scheduling, Trading, Marine, Exchange
- Procurement
- Engineering
- Tank and Technical Support
- Environment Health & Safety
- Commercial/Distributor Sales
- Dispatch Center

External

- Pipe, Valve, Fitting Contractor
- Tank Cleaner
- Tank Inspector
- Disposal Company
- Tank Repair Company

Planning Scheduling & Administration

- Identify and notify all impacted departments
- Review old tank records
- Optimize dates given all internal needs
- Obtain insurance
- Finalize contract administration
- Scope work, write RFP
- Analyze RFP replies
- Qualify contractors
- Review State & Federal requirements
- Obtain alternative product supply
- Engineer alternative piping/storage
- Tank Cleaning Training
- Confined Space Entry Training

Tank Piping Modifications, Product Disposition

- Drain and clean tank for alternative storage
- Construct alternative piping
- Tank lock-out tag-out

Tank Cleaning & Disposal

- Remove product through fixed piping
- Downgrade product

Remove man way

- Pump heel from tank with pump truck
- VOC monitoring
- Squeegee remaining product
- Water wash
- Blow area with fan through man way
- Test for vapors continuously
- Sweep, vacuum interior
- Sand blast

Tank Inspection

- Conduct MFE Inspection
- Conduct Contact UT
- Measure Bottom Settling

Tank Downtime Costs

- Reduce refinery production
- Marine demurrage, short load freight rates
- Additional trucking
- Product downgrading
- Alternative storage
- Alternative product supply

Non-Discretionary/ Just-in-Time Tank Repairs

- Patch plates over bottom areas with >40% of corrosion
- Broken side gauges, floating suction
- IFR/EFR repairs impacting current near term functionality

Discretionary/Premature Tank Repairs

- Patch plates over bottom areas with <40% corrosion

Return Tank to Service, Misc.

- Reinstall man ways
- Remove blinds from lines
- Contract administration
- Payables
- Exchange reconciliation
- Hazardous waste tracking
- Tank record keeping

TECHNICAL TOOLBOXES

Tank operators have accepted the inherently dangerous and uneconomical process associated with the conventional out-of-service process because there were only limited alternatives. Fortunately robotics can now be applied to tank inspections. Robotics are uniquely suited to work in hostile environments that require repetitive and precise actions. The robotic process for tanks involves a robot tethered via an umbilical to an advanced control and monitoring system. The robot is lowered to the tank bottom, while the tank is in service, and navigates across the tank floor using a navigation system capable of mapping the tank floor and location where UT data is collected. A heavy duty pump on the front of the robot removes water and sediment to clean the floor plate, and a series of immersion transducers in the middle take UT thickness readings on the tank floor to measure top-side and bottom-side corrosion. Elevation transducers measure floor plate settlement under product load to determine stress levels on plate welds. The inspection and resulting full engineering report satisfy API 653 guidelines and provide more extensive UT and elevation than available with the conventional out-of-service process. If repair work is required, it can be scheduled in the future and competitively bid to minimize repair expenses and plant disruption. The benefits of the robotic process include:

- Reduced Project Planning – since the tank will not be out of service during the inspection process there are no scheduling difficulties. The planning process also requires fewer internal resources and contractors since the project is simpler.
- Reduced Safety and Environmental Risks – since there is no necessary movement of product from the tank and no requirement to vapor-free the tank or place personnel inside of it.
- Elimination of Supply Related Costs – there are no supply related costs associated with tank downtime.
- Defer Tank Repairs – tank repairs can be delayed until the optimal year, and planned and administered for the lowest repair cost and disruption.
- Maximize Asset Lifecycle – establish a database on the lifecycle and reliability of the floor, and monitor more frequently than is practical with conventional process.



Case Study

Situation

There is a light product terminal owned and operated by a mid-sized energy company in the Southeast. The company needs to inspect their one 100' diameter Regular gasoline tank (common problem since the introduction of new gasoline grades is not accompanied by additional tankage) which breaks suction to the loading rack at 18". Prior to starting the project there are numerous planning and scheduling activities. The terminal operator works through the supply and trading departments to purchase Regular gasoline FOB Rack at a competitor's terminal. The traders naturally pay a premium for temporary product coverage since the lot is relatively small and a terminalling fee is imposed. Loading rack customers like distributors are notified about the temporary product arrangements so their lifting patterns can be adjusted. The engineer begins the coordination process for numerous contractors: providing temporary tanks and pumps, tank cleaning, equipment rental, waste hauling, etc. Terminal operators must also work with dispatch centers since their own trucks will be less productive loading Premium and Regular at two locations for each delivery. A company trained safety specialist for tank inspection is located for the scheduled cleaning and inspection process.

Out-of-Service Solution

The project starts by draining the tank via the loading rack until it breaks suction. The remaining 45,000 gallons consists of 35,000 gallons of saleable product and 10,000 gallons of water/sediment. Since there is nowhere to put the Regular gasoline at the terminal, they give it to a waste processing company and pay \$0.11/gallon plus freight for disposition. The real cost to the energy company is \$0.11/gallon plus \$0.75/gallon for the saleable product.

During the cleaning and inspection process, the company-owned trucks must load at two sources for each trip. Distributors and other loading rack customers are equally inconvenienced; sometimes they choose alternative sources for supply to avoid the additional logistics cost. Finally, pipeline deliveries need to be juggled since the customer cannot make the Regular gasoline off-takes.

Unfortunately the inspection indicates repairs are required. The repairs are not required immediately but rather than put the tank back in service and clean it a second time for repairs, the repairs are scheduled for completion right away. The operator urgently needs the tank back in service so the company waives the bidding process for selecting a tank repair contractor. Instead, they find the first qualified contractor who can start work immediately. The company has incurred significantly higher costs since 1) contractors charge more for emergency requirements, and, 2) certain repairs have been accelerated into the current year so that the tank can remain in service for the foreseeable future.

Robotic In-Service Solution

After a brief planning process, the robotic process starts by lowering the robot into the tank. Tank sludge removal is optional for the customer but not required since it is not



affecting product quality and does not interfere with the inspection process. The full inspection is completed with a three person crew over a period of four days. The tank stays in service during the entire process. After the data is collected and analyzed, a full engineering report is completed for the tank.

Following is a cost comparison of the out-of-service method and the robotic method.

Figure 2: Cost Comparison of Out-of-Service vs. Robotic Inspection Methods

	Out of Service	Robotic
Direct Costs:		
Tank Cleaning (estimated):	\$10,000	\$0
Tank Inspection (estimated):	\$ 5,000	\$33,500
Waste Processing		
11¢/gal x 45,000 gallons	\$ 4,950	\$0
Transportation	\$ 6,750	\$0
Total Direct Costs:	\$26,700	\$33,500
Indirect Costs:		
Planning and Administration	\$ 5,000	\$500
Saleable gasoline sent to reclamation company		
\$0.75/gal x 35,000 gallons:	\$26,250	\$0
Product Differential (1)		
Storage & Handling (600,000 x 2¢/gal):	\$12,000	\$0
Small Lot (600,000 x est. 2¢/gal):	\$12,000	\$0
Truck Loading and Admin (2)		
120 loads at est. \$50/load	\$ 6,000	\$0
Premature Repairs	\$ 25,000	\$0
Total Indirect Costs:	\$ 86,250	\$0
Total Costs:	\$112,950	\$ 34,000

Summary

Since the inception of API 653, operators have had just one method for inspecting tanks: the out-of-service method which requires product and vapor freeing the tank. The out-of-service method has significant health, safety and environmental ramifications and is expensive once the hidden costs are considered. New robotic methods benefit storage tank management – reducing the health, safety and environmental risks while saving costs. Now that many tanks are approaching the second wave of inspections since the introduction of API 653, tank owners have a new, cost effective inspection tool to tame the process.