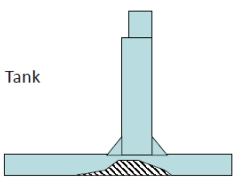
Technology brief:

Short-range HOMC ultrasonic guided waves redefine annular plate inspection quality

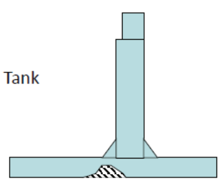
Online inspection modality and detailed quantitative data output enables greater throughput

Different types of corrosion in the critical zone

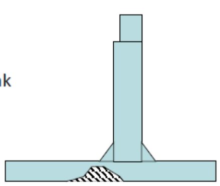
Fuel Oil Tank



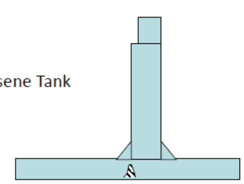
Raffinate Tank



Crude Tank



Kerosene Tank



Beyond view and beneath thousands of gallons of oil, gas or chemicals, between bottom plates and pads of crushed stone or concrete, corrosion builds. Unseen and unchecked, its impact is myriad and exponential, ranging from leaks that are merely costly to ruptures that are catastrophic. Just attempting to detect corrosion in the annular plate region and other areas of petroleum storage tanks can be disruptive, requiring that they be emptied for internal inspections and cleaning that carry their own safety hazards while also necessitating that the massive containers be taken out of use, an enterprise with significant considerations of its own.

Principally, the questions are about cost, financial and more serious. There are 10's of thousands of storage tanks scattered across the World that are 30 years old or older. Increased demand does not produce additional infrastructure, leaving the state of risk unchanged in the current stock of tanks. Instead, products are cycled through existing tanks more quickly. This can heighten the complexity of already difficult choices operators must make when determining the timing of inspections.

The historical view

The means to store oil and hazardous liquids has changed considerably over the last century and a half. Wooden barrels, once the mainstay for storing any liquid from water to olive oil and spirits, both drinkable and not, eventually gave way to riveted steel tanks. In 1922, Underwriters Laboratories unveiled the storage tank industry's first standard. Dubbed the atmospheric aboveground steel storage tank standard, UL 142 (Steel Aboveground Tanks for Flammable and Combustible Liquids), it presented new guidelines for a growing industry.

By the mid-20th century, arc welding replaced rivets for many tank manufacturers, leading to larger, higher quality tanks. The additive weight and pressure loads of the larger tanks created new concerns for tank safety, particularly at the critical annular plate-to-shell junction. This ushered in a new set of standards, including the current American Petroleum Institute (API) 653, which calls for assessing corrosion of the shells and bottoms of the behemoth storage containers.

Industry standards from the API provide recommendations for tank inspection, but these are based on the calendar and not always practicable. Operators faced with the prospect of tanks being empty for weeks must weigh risk and hope to make the correct calls based on analysis of data that are sometimes incomplete and therefore insufficient, leading to decisions based on educated guesses and informed hunches rather than the kind of concrete information they would much prefer. The questions are constant and nagging: How can the operator ensure the tanks in greatest need of inspection are getting it and how can the life be extended for those containers deemed fit to remain in operation?

Corroded annular plate

An operator's answer can have life-and-death implications. More than a dozen people have been killed in oil tank incidents in the U.S. since mid-2010, according to federal records. Even when outcomes are not tragic, the price of an incident is significant, with financial costs stretching into the millions of dollars.

Inspection necessary, but a historically flawed process Internal tank inspections are relatively infrequent though exhaustive. However, these inspections have not proved a panacea. Scanning coated and uneven tank floors frequently has failed to turn up the corrosion in the annular plate region, where water can be trapped, and corrosion can spread between the tank shell, bottom plates, and ring wall. Inspection, cleaning, and repairs can be expensive and hazardous.

Furthermore, only once tanks are emptied – and the meter starts running on downtime – can the work proceed. Examination of floor thickness thresholds—usually through magnetic flux exclusion, or MFE, for unlined floors and saturated low-frequency eddy current, or SLOFEC, on floors with thick film internal liner are typical though limited approaches.

The process is arduous and time-consuming. If it's not handled carefully, hazards can be missed. Timing sometimes can be flawed, based simply on how many months have passed between the previous and current inspections and failing to take into account a wide range of other factors, some known and others not, ranging from fill and empty cycles to environmental changes to variances in operating conditions. These realities all have spurred the search for a better way, leading to new practices and methods including one that stands out against the others.

Most companies prioritize non-intrusive inspections or those that do not require internal examinations and the corresponding shutdown of tanks. These inspections augment internal inspections; their benefits are significant:

Safety: No one enters the tank, where the confined space and products involved can form a fatal combination. When operators can keep inspection crews outside tanks and gain information of equal value, it's a win on all counts.

Efficiency: The tank continues to remain in use, with the need to empty it eliminated and additional costs for downtime avoided. Further, the tank itself is undisturbed. Neither paint nor insulation stripping must be removed, nor must scaffolding later be brought down. The tank's operational life is uninterrupted.

Speed: While internal inspections take time not only to conduct but to provide results, non-invasive methods provide relatively instant data and answers. The quick flow of data allows more rapid response when problems are found. That, in turn, keeps tanks running and helps operators avoid tank failures.

Planning: Internal inspectors frequently are unaware of the conditions inside the tank they enter. Non-intrusive inspections provide valuable data for teams before they go in. This not only makes those inspections safer, but it also expedites planning for them and allows for more exact timelines.

Traditional methods are applied in non-invasive inspections, which include the use of ultrasonic thickness measurements on the tank shell and roof for corrosion and visual inspections of stairways and ladders, gauging systems and vents. However, these techniques cannot be relied upon to tell operators what they need to know about the interior of the tank. To get those answers without going inside, more advanced techniques are required. And, those are all about using more advanced technology.

Guided wave sets the new standard for inspection

Whether inspectors are working the floors inside a tank or seeking to examine it non-intrusively, getting to the most critical areas is a daunting challenge. As operators know well, corrosion frequently lurks within the first few inches of the annular plate and the tank shell wall, a location conventional floor scans can't reach because of the size of the scanners and the weld toe.

Guided wave sets the new standard for inspection

The importance of this region can be lost on those who fail to recognize the sizable stress it faces from the weight of the tank wall and the likelihood of water entrapment beneath the annular plate, both factors combining to help hasten corrosion. Failing to identify corrosion here can be costly, and tank failures can be sudden with little or no warning. Repairing the annular plate means replacing it, and that translates to a prolonged shutdown of the tank.

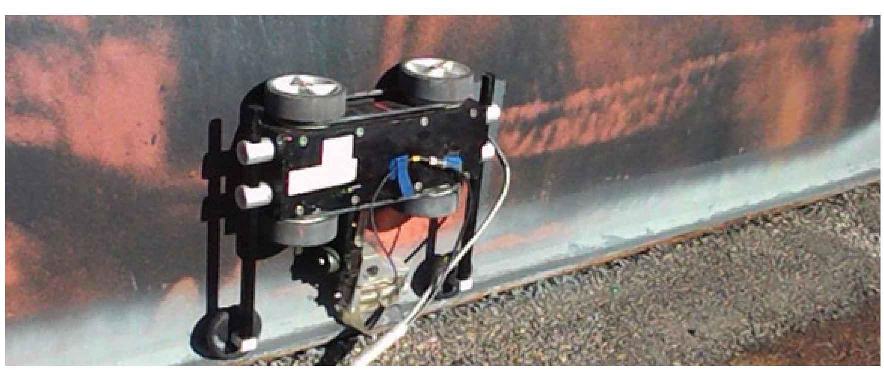
But internal inspections can't be counted upon to prevent this. The reasons are multifold:

- Floor scanners cannot reach the region from the toe of the shell to the annular plate inner weld.
- The lack of access at the weld toe strips the capability of ultrasonic thickness measurement to identify the problem.
- Corrosion under the inner weld toe is extraordinarily difficult to identify.
- Corrosion can be highly localized, to slightly more than 1 percent of a tank's circumference—making it more easily missed.
- Surface conditions and length of the chime region can render it inaccessible for some methods.

Internal inspections are limited principally by the quality of the inspectors because they rely so heavily on the ability of those crews to spot the telltale signs of corrosion. Magnetic flux exclusion, also known as magnetic flux leaking, or MFL, is an essential component of many tank inspections, but it can't extend inspectors' eyes to the annular plate region.

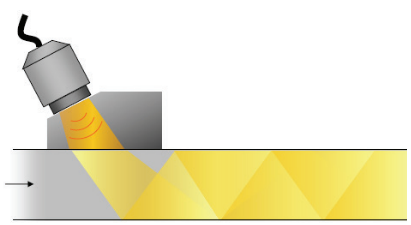
So how then to resolve the problem? Waygate Technologies, a Baker Hughes business, has an answer, based on pioneering work by Dhvani Research. The Chennai, India, firm has patented a technique using short-range ultrasonic guided waves relying on higher order modes clusters, or HOMC. The waves modes are reflected from corrosion and other features of the annular plate. Inspections can be conducted even while the tank is in use.

High frequencies, minimal displacement on plate surfaces and the absence of dispersion helps inspectors get to regions that otherwise are inaccessible.



HOMC guided wave inspection key characteristics:

- Unaffected by weld toe
- Very small Dead Zone
- No wave mode selection
- Easy to interpret data
- Unaffected by product in tank
- Does not discriminate top/bottom side flaws
- Sensitive to sharp and restricted corrosion, cracking and pitting
- 6-12 inch inspection distance within the tank
- Projection length of 35-45mm chime is sufficient



A robotic scanner expedites testing well in line with industry requirements. While the size of the chime is a sizable consideration in the use of most inspection technologies, which require roughly 2 inches, Waygate Technologies' system can handle the work on chimes as small as 25 millimeters. Field tests conducted across continents and around the world demonstrate that it works.

Applied by major oil companies globally, the technology offers a vast range of benefits. Oil majors have found it to be the most reliable technology of its kind. It allows for online and quick inspections of the most vulnerable regions of the tank and permits planning in advance of a shutdown rather than crisis responses to the sudden need for a new annular.

One oil major used the technology on 100 tanks and avoided five major leaks. Defects additionally were found in a total of 300 tanks across Europe, Asia Pacific and the Americas.

Battery-operated and rugged, the technology is tried and tested and is emerging as a true difference-maker. Its efficacy makes the service provided by Baker Hughes highly cost-effective, particularly in consideration of its high efficiency and the massive savings it generates by enabling operators to limit and prioritize downtime. This allows plant managers to prepare for tanks to go offline and know with certainty how long the containers will be down and when they will be returned to service. The technology removes variables and guesswork and supplies in their stead clear data that provide a firm foundation for effective decision-making.

Waygate Technologies' system relies on sound physics to produce sure, irrefutable facts and the company's expertise in the industry as the world's only provider of integrated oilfield products, services, and digital solutions. While technology is a differentiator, it's only as effective as the people running. This is why Baker Hughes insists that each member of its on-site inspection teams be highly Certified and qualified to perform these inspections.

Corrosion, which spreads in places unseen, no longer can remain concealed in the once-inaccessible annular plate region, not at least when HOMC technology is in use, and the robotic scanner is rolling.

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