AUTOMATIC TANK GAUGING

The value of a trusted device

Abstract

ATGs have been around for decades but few products have been trusted to the point of using the device as a de facto standard. With the right device, ATGs help increase overall production for the field, management, and the entire company which is the shared common goal for everyone.

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BACKGROUND

In the oil and gas industry, hydraulic fracturing (fracking) along with horizontal drilling and the utilization of multi-well pads has allowed producers to maximize returns from each location. As a result, extremely large volumes of oil and liquids are being produced on a daily basis from each site. However, the multiphase flow characteristics of these unconventional wells make accurate tank gauging extremely challenging as wells will produce varying amounts of oil, water, condensates and natural gas components. Regardless, tank gauging in itself is an essential element of inventory control and custody transfer, enabling any Blockchain strategy as well as having the ability to provide leak detection. Therefore, extremely reliable and accurate tank level measurement is essential to each producer's operation. Automatic Tank Gauging (ATG) provides a means to automate this process, allowing producers to reduce costs, maximize efficiency and provide a safer work environment for all employees.

Automatic Tank Gauging technology has now been around for a couple of decades, but few products have been trusted to the point of using the device as a de facto standard. While many products have been introduced into the market over the years, the challenging process conditions make it extremely difficult to operate reliably enough to meet the expectations of the industry. Not only are these unconventional wells producing oil, water, condensates, and natural gas but they are also producing corrosive gases that can destroy level sensors in a matter of weeks. In addition, paraffinic buildup and scaling can occur on a level sensor, dramatically impacting the accuracy of the measurement, leading some producers to pull their sensors every 30 days for maintenance. However, some manufacturers have fortified the technology, hardening the product offering which has led to increased reliability and accuracy.

The components of an ATG consist of the level sensor and either a wired or wireless transmitter head as illustrated in Figure 1 to the right. The sensor can either be rigid or flexible and is sized based on the actual tank height, providing some contingency for adjustability during installation. For most applications in shorter or turbulent tanks, a rigid sensor is utilized. The rigid sensor seats all the way on the bottom of the tank and is provided with either one or two floats. While a single float will measure top-level product only, the dual floats will measure both top-level product and the product/water interface level.

The sensors are also supplied with an integral RTD for temperature measurement of the fluid in the tank. For taller tanks, especially those that are 15' and above, a flexible level sensor is installed. The value of the flexible level sensor is that one person can complete the installation in a matter of minutes whereas with a tall rigid

Figure 1. Components of an ATG

sensor, multiple people or even a crane would be required to complete the installation. Like the rigid sensor, the flexible sensor is provided with either a single float or dual floats. However, unlike the rigid sensor, the flexible sensor hovers slightly above the bottom of the tank and utilizes a weight kit to keep the sensor taught while allowing for minimal thermal expansion and contraction.

The transmitter head can either be wired or wireless and secures to the level sensor via a quick connect connector that is just hand tightened, making the installation very easy. The wired transmitter head is externally powered and may be daisy chained to other wired transmitter heads using RS-485 in a multi-drop fashion. In this case, intrinsically safe barrier boards must be used to maintain area classification between the hazardous and non-hazardous locations.

The wireless transmitter heads are completely self-contained, battery-powered and intrinsically safe. By being intrinsically safe, these wireless transmitters can be installed in Class I Division 1 environments where there are always explosive liquids, vapors, and/or gases present, and the transmitter will not generate enough energy to even cause a spark in the hazardous environment. The battery life achieved can be up to 10 years based on user defined transmit intervals of 45 seconds and greater. This includes powering the sensor as well as the wireless transmitter.

As a result of these benefits and Return on Investment (ROI), wireless ATGs have been adopted by many large producers. From an architecture perspective, the wireless ATG transmitter heads report back level(s) and temperature measurements at user-defined transmit intervals to a wireless Gateway.

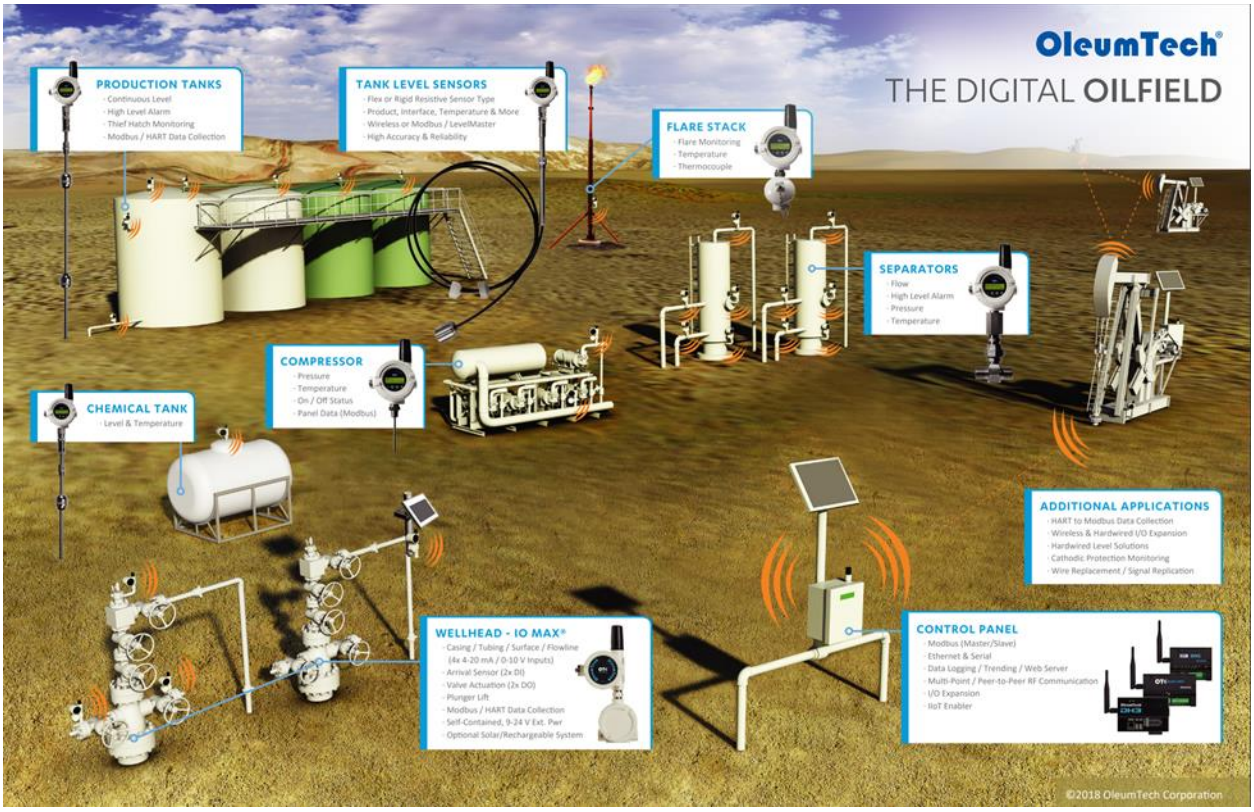

Figure 2. The Digital Oilfield

The wireless Gateway is a point to multipoint device acting as a data aggregator, offering tremendous economies of scale as it will support dozens of wireless transmitters. As shown in Figure 2 above (The Digital Oilfield), this enables producers to bring back more than just tank data. For the incremental cost of the sensor and wireless transmitter, the same gateway can accommodate wellhead pressures, temperatures, flows, etc.

Another significant advantage for wireless over wired is that wireless is not susceptible to noise being introduced into the system such as some wired architectures. This noise could be introduced into the system from a water hauler with a pump that is not properly grounded where the pump is creating static electricity and feeding into the facility. Without proper grounding, a wired system will see this as noise, impacting communications and the accuracy of the measurement. The noise could also be introduced by thunderstorms passing through the area. In addition, oil field growth is outpacing electrical infrastructure buildout. Using self-contained, battery-powered wireless sensors minimizes power requirements for each site.

BUSINESS JUSTIFICATION AND RETURN ON INVESTMENT (ROI)

Many producers look at the initial cost of ATGs and assume that automated tank gauging is cost prohibitive. However, a device that is trusted, provides true value all the way through custody transfer. This makes the Return on Investment (ROI) much sooner than most realize, especially when looking at key performance indicators (KPIs). The most intuitive, is that from a KPI perspective, every employee has an hourly wage associated with them.

For example, let's say a facility has 3 tanks where the person is properly gauging and checking bottoms. It is estimated that the person will spend approximately 20 minutes on the tanks. Next, let's extrapolate that out to 25 sites, every day, 365 days a year. With a trusted device, visits can be cut to four times a year, just doing quarterly calibrations. How much money was saved? More importantly, how long did it take for the ATG system to pay for itself? While producers can enter their own hourly wage KPI numbers into the formula to extrapolate individual ROI, the short answer is not long at all.

BENEFITS

The beauty about ATG's benefits are that they go well beyond just the immediate ROI. In addition, efficiency and visibility are greatly enhanced. For instance, if fracking on a new well and happen to hit other wells in the area, producers now have that visibility. Since all well sites are communicating and reporting back tank information, now all of a sudden, these wells are producing tremendous amounts of water and wells that did not need supervision, now need a flow back unit on each site.

The value of having a trusted device on the tank is that while a flow back unit on each site may be needed initially, the probability of having personnel on site for the long-term is minimal. The reason is producers can just have one resource going from site to site to double check operations once or twice daily. Efficiency is greatly increased, and additional resources saved by not having to deploy dedicated personnel on each site.

Also, from an efficiency perspective, dispatchers have visibility into the entire field. Therefore, analytics can be utilized, allowing reports to be generated every 12 hours (i.e. 6 AM and 6 PM). With the information contained in these reports, key personnel throughout the organization know exactly what is in the tanks and what they are hauling. In addition, data is available to optimize routes as some sites may not even need to be visited, having not produced any oil at all. Otherwise, it would just cost money and time dispatching trucks for zero benefit. This also enables the company to tell whether a site produced more than it was supposed to or didn't produce any oil at all, providing additional insight that the gas lift or compressor went down. It also provides the visibility that there is oil in a water tank. Regardless of the scenario, personnel can be notified to take corrective action to prevent any long-term impacts on operations and tank inventory.

One of the other significant benefits of having ATGs is the surveillance aspect. Many people in the industry are going to cameras which from a visual aspect, is understandable. However, what is that visual really telling producers about their equipment and what is actually in the tank? Also, there are some in the industry migrating to acoustics but as soon as a thunderstorm passes through, the baseline is skewed, creating significant headaches for not much value.

Lastly, safety is perhaps seen as one of the biggest benefits of having a trusted device. With a trusted, field proven device that is only being visited four times per year, top of tank exposures are limited, thereby reducing human exposure to hazardous environments. In addition, by making the truck drivers, water haulers, and oil haulers more efficient, the roads are safer for everyone.

WHAT MAKES A DEVICE TRUSTED?

Obviously, a lot has been mentioned above about the ROI and benefits of a trusted device but with all the history of ATGs, what makes a device trusted? Recently, I had the opportunity to ask an automation technician at one of the world's largest producers this very question. Before answering, he shared that prior to his current role, he was a production specialist focused on downhole applications. As part of his role, he worked in slop facilities which required taking the worst of the worst liquids and make them into good oil. Therefore, he had to understand fluid properties better than anyone. As a result, when looking at tanks compared to other people, he understands that the conditions of the tank have a significant impact on ATG performance.

While the easiest thing to do is to blame the device and say it is wrong, is it? Typically, what happens is that a technician is dispatched to travel to the site and calibrate the device. However, without truly investigating what actually caused the inaccuracy, the assumption is made that something is wrong with the device or perhaps, it has drifted. The recalibration may very well be introducing additional error into the measurement. In reality, something changed within the tank and now when fluid is rolled, the measurement is now out of tolerance based on the offset introduced during the recalibration process, resulting in self-inflicted issues.

By going through the investigation process and ultimately understanding exactly what is happening in the tanks, the device becomes proven and trusted over time. Therefore, when issues arise, the focus of evaluating root cause goes beyond blaming the device. It allows companies to focus on the device last and eliminate everything else first, instead of running in

circles, wasting time and resources. This approach also eliminates the undesirable potential of calibrating the device out of tolerance only to find when conditions stabilize and return back to favorable within the tank, the offset introduced becomes the actual issue.

During my conversation with the automation technician, he shared that they consider a failure more than just a failure. They categorize failures based on their own experience as defined below:

- **Operational failure** - really falls within human error in terms of who gauged the tanks? How they gauged the tanks? How long were they turned out of the tanks? What was the temperature? What was the condition of the fluid? If the tank has been sitting stagnant and the temperature is 30°F or below with paraffinic oil, and chemical(s) are not being injected into the tank, they know from experience the float will be sitting slightly higher on the fluid than when starting to produce into it. If that happens to be the time the device was calibrated, an error was just introduced.

- **Mechanical failure** - this failure falls in the category of the wired or wireless transmitter head that is connected to the sensor, including a depleted battery. It could also be a result of an issue with wireless communications from the transmitter to the wireless gateway. It could be as simple as a new RTU that was connected to the gateway and the communications interface settings are incorrect in terms of baud rate, parity, stop bits, etc. or could just be the result from a lightning storm in the area that caused damage to an antenna.

- **Device failure** - this is actually where the level sensor fails. With a trusted device, operational and mechanical failures are ruled out first and this is the last part of the troubleshooting process. In reality, the device should be the last thing that any producer must worry about.

As mentioned above, ATGs have been installed for decades and have a lot of history. With the challenging conditions the devices are exposed to, much of the history is not good. Therefore, the culture in the oil field industry is to not trust the device. That being said, it is important to note that not all ATGs are created equal. Regardless, for some, manual tank gauging is seen as superior over ATGs but that is not the case. It could be as simple as looking at it from the perspective of having two different linear devices.

The first is a fixed length, digital linear device. The second is a mobile linear device which has many moving parts and variables, including a plumb bob (or plummet). In addition, it could be a windy day, rainy day, hot day, or any combination thereof. A tank gauger can simply walk on top of the tank and drop his device into the tank but where was the plumb bob actually placed? How was the level actually checked with the device and was it identical to the previous check? What is more likely to introduce the error, the fixed length digital linear device or all of the random variables introduced with the mobile linear device? While the answer is clear, there are still people in the industry that put trust in the mobile device.

From a temperature measurement perspective, the digital device is more accurate and consistent. This is because that even though the temperature is being taken from one consistent spot, the temperature is taken at the beginning of the load but then the tank is stirred during the

load, allowing for better temperature transfer. This means the temperature reading is better than simply going in and averaging temperatures from the bottom to the top of the tank as the sun could have possibly been on the back of the tank, introducing even more variability in the overall temperature reading.

With ATGs, the temperature is taken at the front of the tank where it's going be more consistent with a digital field device than a hand gauging method. Just that alone makes it more efficient. This is lost on many people simply because they do not understand fluid properties with respect to temperature transfer. In the summer, this temperature transfer is much faster because as things heat up, molecules move much faster, therefore the temperature transfer is much faster. In other seasons, especially where the temperatures fall dramatically during the night and rise during the day, the temperature swing throughout the fluid will be dramatic. In addition, if the tank has water pockets or any emulsion, temperature variations will exist throughout the tanks as water will hold temperature better than the oil does. This means pockets could exist within the tank that are as much as 7°F off from the rest of the tank.

OTHER TECHNOLOGIES

While the best success has been had with float-based, resistive technologies, there are certainly other technologies out there. Some use Hall effect type sensors that do have advantages in terms of resolution and are very consistent, limiting the amount of drift that can occur but do have drawbacks in terms of robustness. In addition, they are not intrinsically safe and do not offer the ability to seal them. In addition, the transmitter head does not have an available local display to allow the operator to be able to read the tank variables directly from the top of the tank nor does it have a wireless transmitter head offering.

Guided Wave Radar (GWR) is another technology that has gotten a lot of traction in the past few years which uses many formulas embedded in firmware to calculate and identify where the product level is, as well as the water interface level. However, it's unclear that it adjusts to the conditions of the tank as well as a float-based technology. As a result, most companies will have to employ personnel to go and check these devices on a regular basis.

In additional to these frequent checks, many GWR manufacturers recommend pulling and cleaning the sensors due to scaling and paraffinic buildup concerns. Both conditions cause false readings and because of the potential for measurement error since all the variables are being calculated, it acts much like a nonlinear device. Whereas, having a linear device, pushes out these checks to a quarterly basis resulting in significant savings in terms of maintenance costs and results in an immediate payback for the deployment of ATGs. Perhaps the most alarming feedback received is that most producers do not actually pull the GWR sensor for cleaning, they access the cable through the thief hatch which is a clear violation of safety standards and puts employees in harm's way.

This also means that when these quarterly checks are performed and the top third, middle third, and bottom third of the tank is seen within tolerance, it is considered a "calibration", meaning the device does not actually have to be touched. With guided wave radar, this is not the case as a minimum of annual calibrations are required. From a cost perspective, imagine if the field consists of 100 tanks. There is considerable cost associated with this, as full-time personnel would

be required just to do annual calibrations. Plus, a truck must be dispatched to move the fluid around in the tanks just to be able to achieve the top third, middle third, and bottom third calibrations. Therefore, two people and two trucks must be dedicated to this effort year-round just to maintain the devices, not to mention the time it takes to move the fluid around in the tanks.

To alleviate the scaling and paraffinic buildup concerns, some of the resistive, float-based technologies have fortified the design through material selection and float design. The end result is a sensor design that provides reliable, accurate level measurement without requiring the routine maintenance as do the other technologies. Providing additional confidence to producers, these manufacturers have gone so far as to provide a limited lifetime warranty against H2S damage, scaling, and paraffinic buildup.

CONCLUSION

As noted, the multiphase flow characteristics of unconventional wells make accurate tank gauging extremely challenging. However, today's sophisticated ATGs can measure levels for two liquids to within an 1/8-inch accuracy over the height of any tank and provide temperature measurement to allow sellers and buyers to reconcile volumes based on temperature which is paramount for any Blockchain strategy.

At the end of the day, ATGs are capable of doing way more than the majority of companies realize. Most companies seem stuck on lease custody transfer because the perception is that it is much harder to implement than it actually is. However, with a trusted device, not only can short-term ROI be achieved but as shared throughout this paper, there are many other benefits to having a field proven, trusted device.

Automation is just one piece of the overall puzzle that can directly affect the efficiency of how companies produce on wells. With an ATG, while resources are still visiting the site, less time can be spent on the actual tank(s), providing for more time on the separator, a chemical tank, a pump, or whatever is local to that site. As a result, ATGs help increase the overall production for the field, management, and the entire company which should be the shared common goal for everyone involved.

ABOUT THE AUTHOR

Brent McAdams is the Sr. Vice President of Global Strategic Initiatives for OleumTech Corporation and leads the company's OEM efforts as well as developing strategic partnerships to deliver a global IoT strategy, including edge-to-enterprise solutions. Mr. McAdams has appeared in a number of publications, including Pipeline & Gas Journal, Control Engineering, ISA InTech Magazine, and Plant Engineering as well as being a featured speaker at industry events around the world.