

Salt Water Disposal Leak Detection



OVERVIEW

Saltwater disposal (SWD) pipelines are typically short — less than three kilometers, or under two miles in length — but when they develop a leak, they can quickly cost hundreds of thousands of dollars' worth of damage in repairs, remediation fees, fines and lost production during regulator-mandated shutdown time. Alberta Energy Regulator (AER) quoted statistics that indicated 1.1 incidents per 1,000 kilometers of pipeline in 2016.

Because of the high concentration of salt in SWD water, any spill left unremediated would render affected land unusable for agricultural purposes for decades. Remediation must therefore include removal and treatment of dirt to a depth of many feet. Costs can easily exceed \$130,000 US.

Monitoring SWD pipelines has been problematic due to their short sections. Flying a plane or a drone across great lengths of petroleum pipelines — crude, gas or refined product — is much simpler than monitoring scattered pipelines of one to two miles, or three kilometers.

With the dawning of the age of remote monitoring, producers have justly decided that correctly placed sensors tied to a communication system can give them the information they need to quickly and economically spot leaks. This would allow them to quickly shut off pumps and dispatch repair/remediation crews, all while keeping spill volumes minimized.

THE INEVITABILITY OF FALSE ALARMS

Data can be gathered by monitoring inflow and outflow volumes, and comparing the numbers along with pressure, flow and pump status. After collecting historical data, operators can set parameters that allow the system to trigger an alarm when the numbers are above or below a certain threshold.

However, not every anomaly indicates a leak, or any other kind of actionable situation.

For example, the assumption could be made that, because water is a liquid, it is not compressible in the same way that gas is, that the volume of water leaving the system should be exactly the same as the volume entering the system. But because few pipelines are straight and level, there are places where the line rises and falls with the terrain, and there are bends needed to navigate around obstacles — all of which put pressure back on the flow. This can delay the water's exit, creating temporary discrepancies between the meter on the incoming side compared to the meter on the outgoing side.

Improved Alarm Management Will Help Offset Rising Disposal Costs. Water disposal costs, which may already make up as much as 25% of lease operating expenses, may add \$6/bbl to operators' break-even costs.

— Woods Mackenzie Study, 2018

Another issue is that many times, when the pump stops, the well itself creates a vacuum that siphons out much of the water that remains in the pipeline, much like a stranded motorist might use momentary suction to siphon gasoline through a hose from a vehicle into their own. If the system assumes a static water volume in the pipeline, whether water is flowing or not, this vacuum action will create another harmless anomaly.

One operator found themselves inundated with approximately 40 alarms per month — more than one per day. Because very few of these alarms indicated an actual leak, field personnel began to ignore them, much as the townspeople did in the Aesop's Fable of the boy who cried, "Wolf!"

This could lead to a situation in which an actual leak might be ignored, allowing it to do great damage to lease property before caught, repaired and remediated — at great cost to the operator.

One way to reduce false alarms is to take readings less often. Some have spread the intervals as far as three hours apart. This will involve reading the amount of water input during that time vs. the amount of water output and figuring a 10% margin of error.

The obvious issue with this scenario is the potential for delay in finding a leak. Also, the 10% margin of error may still allow false alarms — just fewer of them because of the reduction in the number of readings.

In addition to false alarms, the customer was concerned about meter accuracy. They needed a way to manage and prioritize the large amounts of data they were now collecting in order to make it useful without requiring personnel to spend mind-numbing hours reviewing the data.

TRAINING OF ARTIFICIAL INTELLIGENCE SYSTEM TO ALARM

The customer was aware that Emerson's DeltaV SaaS SCADA engineers were developing artificial intelligence (AI) systems that could be trained to separate alarm-worthy incidents from non-emergency anomalies.

The customer gave DeltaV SaaS SCADA the opportunity to monitor a test section of pipe where the operators knew at all times whether all the liquid was flowing through or not. When the sensors detected an anomaly, operators would instruct the machine learning algorithm as to whether this anomaly indicated a leak, or not. With each instance, the algorithm would have one more situation in which it would "know" the difference.

In fact, each sequence of starting and stopping the pump would create a signature — a pattern — which the algorithm would memorize as to whether it was a real problem or not, based on operator input.

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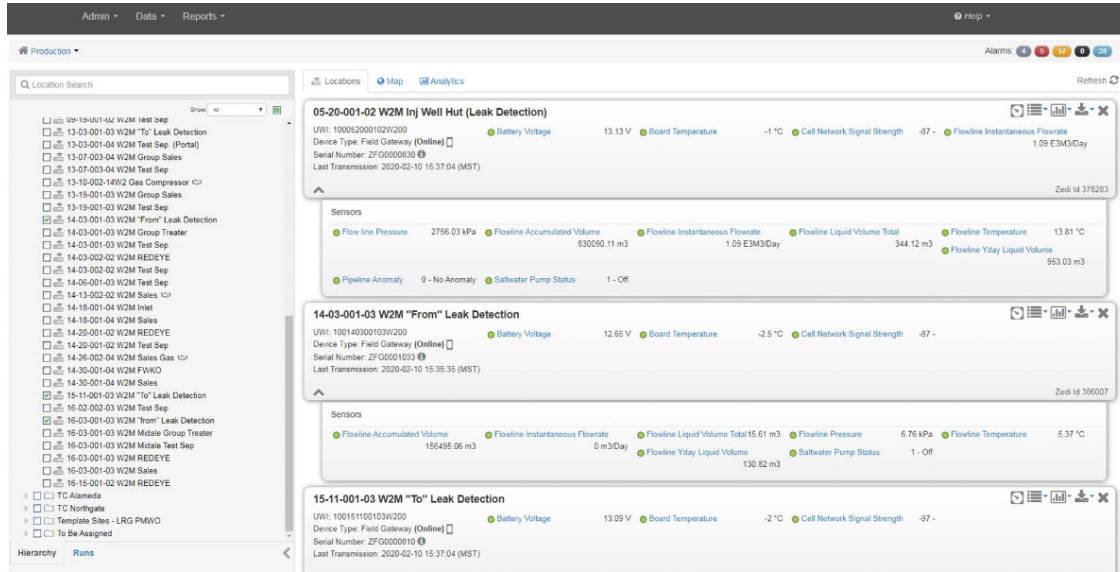


Figure 1. Leak Detection Locations.

When it came time to do a final test, a test section with a turbine meter at either end was configured. A vacuum truck was used to withdraw liquids in increments of 5%, 2.5% and 1% of the flow liquids over a 30-minute time-frame.

During the test, the AI software correctly identified all three withdrawal rates as leaks within a few minutes. It also correctly identified normal pipeline flow transitions without creating alarms.

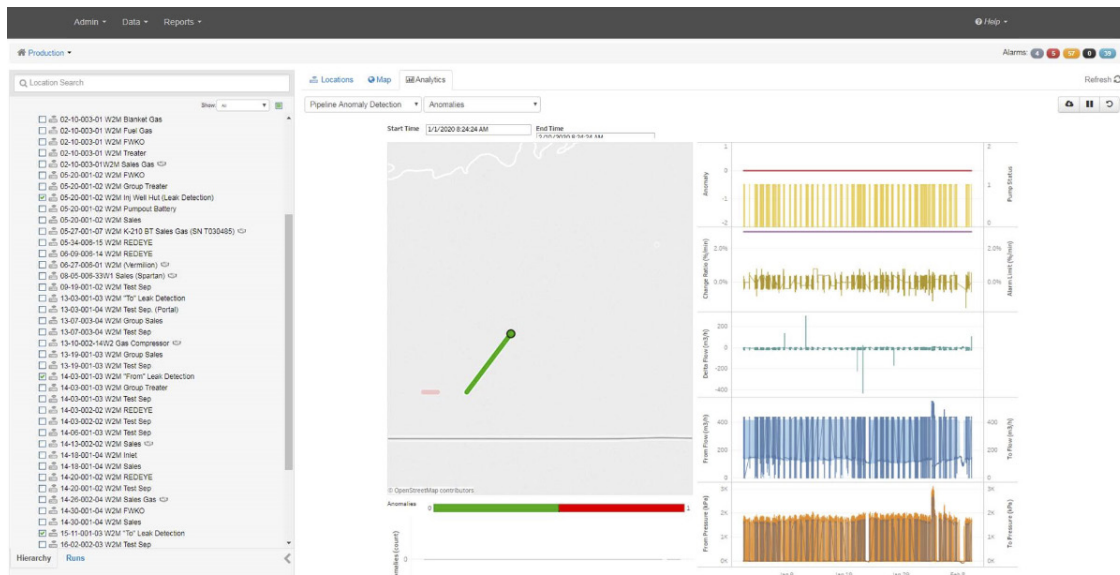


Figure 2. Pipeline Anomaly Detection Analytics.

So far, the system has only been tested on simple systems — one origination pump and one pipeline connected to a single disposal well. Further development is now underway toward the goal of accommodating systems with multiple inputs and single or multiple disposal wells. Leak signatures will also vary based on the inside diameter and length of the pipeline.

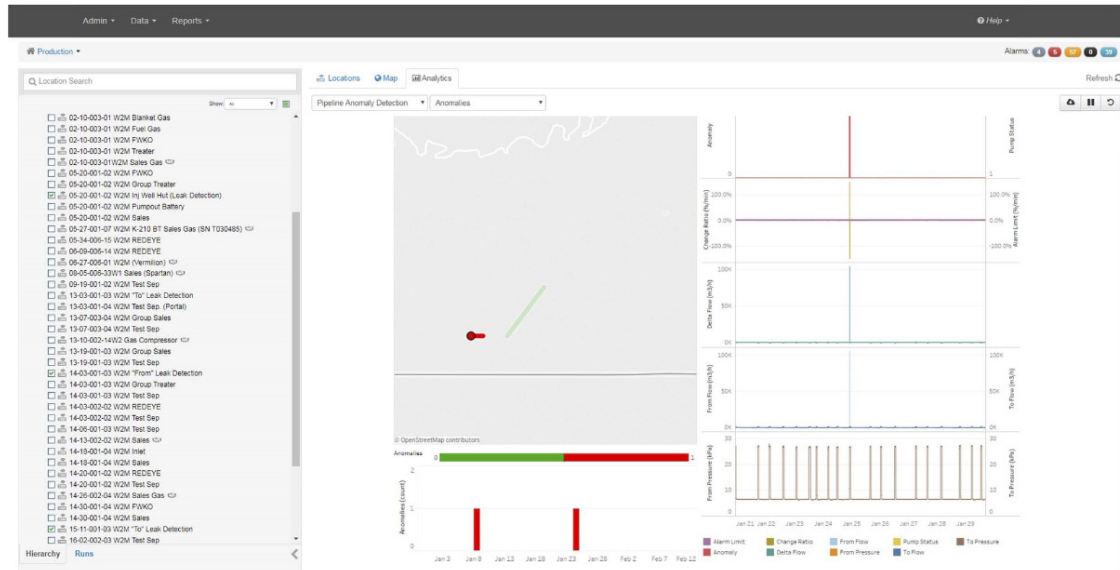


Figure 3. Pipeline Anomaly Detection Analytics.

USABILITY

The nature of machine learning, much like human learning, is to continue to learn — this means it will always be improving its accuracy and expanding its scope. As the software gains marketplace acceptance, monitoring ultimately hundreds or thousands of wells, the database will continue to become more accurate and robust for all users.

After achieving this level of accuracy, there remains one more step to adoption: usability. Field personnel must not only trust the software, they must be able to easily navigate it. Emerson's software team is currently assembling easy-to-use dashboards within Emerson's Zedi Smart-Field software that will distill the pipeline data into useful, easily read charts. These will give information on leaks and on any other data the operator deems pertinent.

While this software does not prevent leaks, it does reliably detect leaks quickly. Operators may now quickly dispatch repair teams to the site in order to minimize damage, accelerate cleanup and ultimately, reduce losses and expenses tied to larger leaks that continue unabated because personnel were ignoring unreliable alarms.

The software also tracks other issues such as pump outages, meter reliability questions and changes in pressure and flow — informing the operator of other repair situations. All of this will be based on the aforementioned signatures. It can also generate daily, weekly or monthly reports for tracking and accounting purposes.

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