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In the pipeline

To catch a pipeline thief

Criminals across the globe are using ever-more sophisticated methods to steal from pipelines. So what can the industry do to fight back? **P8**

To catch a pipeline thief

Fuel thefts from pipelines don't just cost governments and businesses money – they cost lives. But how do you begin to apprehend thieves who have a dizzying array of techniques and tactics to carry out their crimes? Harry Smith, sales and research engineer from Atmos International, looks at some of the solutions to this global problem

Pipeline theft is a serious global problem and has been on the rise for the last few years. In terms of pipeline integrity, thefts are one of the largest risks and they can be hard to prevent without a great deal of strategic focus.

The events in Mexico earlier this year (see box, far right) demonstrated the risks thieves will take and the ultimate price some people will suffer as a result. However, pipeline theft is not restricted to Central and Latin America but extends worldwide with occurrences in Nigeria, Indonesia and China. In Europe, pipeline thefts have also risen with incidents found in Eastern and Southern Europe. Here at home in the UK, theft was designated so serious that the National Crime Agency became involved. The challenge to operators and law enforcement is that there is no single cause of thefts – a wide range of factors including social, economic, political and legal apply.

While some thefts are clearly organised for criminal gain, many are driven by often the most basic of needs such as obtaining fuel for heating and cooking. It is often these small ad hoc thefts that can have the worst consequences.

11 methods for pipeline theft

We are seeing thieves becoming more sophisticated and organised, using specialist equipment such as commercial-grade welding machines, calibrated measuring instruments, night vision goggles, and vans with modified suspension or exit holes built into the floor of the vehicles. Thieves will also sample product to decide if it is the right one to steal.

From a technical perspective, thieves will deploy several tactics including:

1. **Pre-installing the tapping point, hose, associated**

Theft has become so serious that national crime agencies are often involved

An illegally punctured pipeline in Mexico City killed at least 79 people

Mexico's fuel theft tragedy

In January 2019, thieves punctured a pipeline near Mexico City that caused an explosion killing at least 79 people. The blast occurred in a rural, impoverished region and was particularly deadly because the criminals' pipeline breach lured hundreds of villagers nearby with the promise of free gasoline. As well as the terrible human toll, fuel theft is deadly and expensive – it has cost the Mexican government billions of dollars. While the human cost of this tragedy hit the headlines, every day nations across the globe face a similar fight, with the associated human and financial costs.

valves, and equipment before a pipeline is commissioned.
2. Selecting remote and well-hidden sites, including abandoned farms, old factories and other out-of-use buildings.
3. Burying and covering the hosepipe and all other devices underground.
4. Opening the tapping point valves very slowly to generate small pressure change over a long time (perpetrators are known as the patient thieves).
5. Maintaining the theft rate below flow meter repeatability level. e.g. 0.5% of pipeline throughput.
6. Carrying out the theft activities at night.
7. Stealing small volumes of product each time.
8. Injecting water into the pipeline, while taking oil out.
9. Performing thefts at multiple locations along the same pipeline.
10. Using dangerous techniques, including angle grinding and plastic equipment.
11. Adapting vehicles such as old milk tankers or vans with upgraded suspension to handle the weight of fully filled IBCs (intermediate bulk containers).

At worst, thieves have driven stakes into pipelines and used rags to reduce the outward flow. All these different tactics make it difficult for pipeline companies to detect and locate thefts quickly and accurately.

While, previously, leak detection methods were used to reveal theft, a more focused approach is now required. The application of the negative pressure wave and statistical volume balance methods are extremely beneficial for theft detection, with the use of offline analysis and further instrumentation. As every pipeline is different, a one-size fits all approach is not suitable. However, each technology has its advantages and can often be combined to provide an integrated approach. Furthermore, non-intrusive pressure sensors with remote radio and cellular communications and battery powered data logging can provide additional accuracy to support GPS location and offline analysis.

Theft detection technologies

Detecting thieves' activities requires a different approach to detecting leakage. This is because:

- **a small amount of product is stolen (ranging from 10 to 3000 litres)**
- **the theft flow rate can be less than 0.1%**
- **theft events usually last for less than one hour, although occasionally a theft**

- **continues unchecked**
- **the changes in pressure are very small when the tapping point is opened/closed at the end of a long hosepipe.**

With this in mind, the main requirements of theft detection are: sensitivity – detecting the small product withdrawal; accuracy – locating the tapping point as accurately as is possible; and response time: detecting the product withdrawals as quickly as possible.

Different leak detection technologies can be adapted to meet these requirements. The main theft detection options are: negative pressure wave, statistical volume balance, and a theft service approach. We'll look at these options below.

Negative pressure wave

This technology relies on high-speed analog pressure sensor readings to identify whether a leak/theft has occurred on the pipeline. The system acquires and analyses the pressure data at a frequency much higher than the typical five second supervisory control and data acquisition (SCADA) rate, capturing data at 60 samples per second. Specialised equipment is thus needed to acquire data at such high frequency.

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The main advantages of this system are:

- **accurate leak location within metres of the actual location**
- **short detection time for all leak sizes**
- **high sensitivity provided through the 60Hz sample rate.**

These are the key features in effectively detecting theft events in all operational conditions.

Statistical volume balance

This type of leak detection technology relies on the pressure and flow measurements taken from a pipeline. It uses the existing instrumentation and connects via existing SCADA, programmable logic controller (PLC) or remote terminal unit (RTU) systems. This system monitors the difference between the inlet and outlet flow corrected by the inventory change. This is also referred to as the corrected flow difference to determine whether the pipeline is in a leak condition.

The statistical hypothesis testing method is known as the sequential probability ratio Test (SPRT). It is applied to the corrected flow difference to decide if the probability of a leak has increased.

The main advantages of this system are:

- **low false alarm rate**
- **detects leaks under steady-state, transient and shut-in conditions**
- **accurate leak size estimate**
- **leak location accuracy improved through higher data sample rates.**

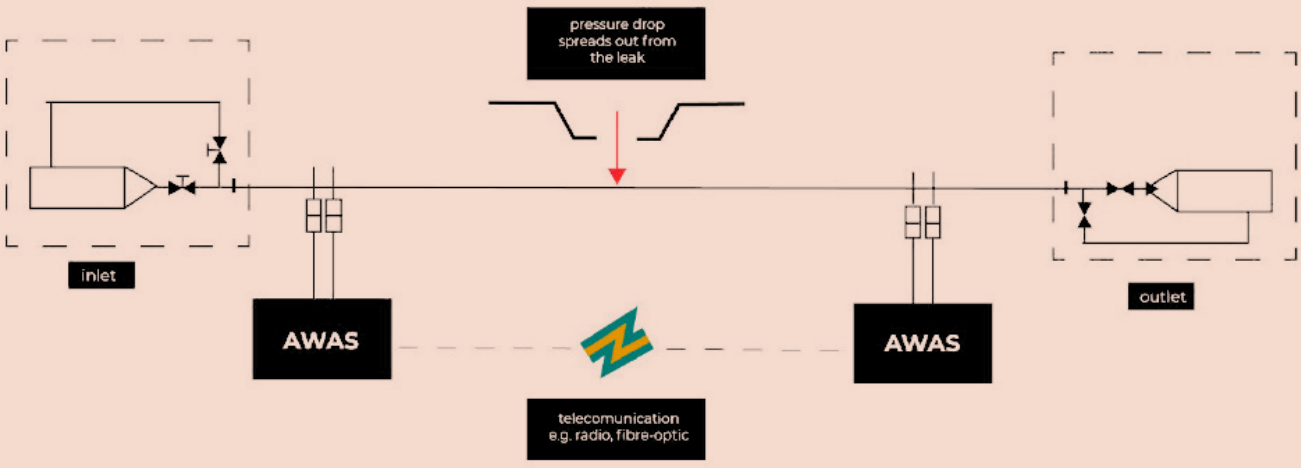
Since the theft rate is usually below the flow meter accuracy and repeatability level, it is difficult for this technology to detect small thefts under running conditions unless false alarms are accepted. The system includes an additional theft module for detecting thefts during shut-in conditions to maintain reliability for both leak and theft detection. Figure 4 shows an example of it working.

Theft approach service

Frequency of thefts are not a constant and can fluctuate. In fact, tapping points are often left unmolested for years. In the UK, a recent tapping point was located that was likely installed as far back as 2015 and left dormant until earlier this year.

When the volume of thefts along a pipeline reduces, it becomes necessary to lower the minimum leak size to be detected. But doing this can result in more false alarms, because the identified flow and pressure are mostly below

Figure 1: Overview of the Negative Pressure Wave System with Atmos Wave Acquisition System (AWAS) units



> ‘We are seeing thieves becoming more sophisticated and organised, using specialist equipment such as commercial-grade welding machines, calibrated measuring instruments, night vision goggles, and vans with modified suspension or exit holes built into the floor of the vehicles’

the instrument repeatability and process noise level.

An offline service can be offered to pipeline companies. Combining technology with this kind of service can provide improved leak location accuracy and sensitivity without unnecessary false alarms.

Deployment of portable and fixed hardware with software solutions allows offline data analysis by an experienced engineer. Through this service, an engineer’s ability to interpret data helps theft to be located down to a few metres, using pressure data collected at 60Hz sample rate and sent to a central location via a cloud-based service.

The data is then filtered to present only the relevant information required and the locations of the illicit tapping points are reported to the pipeline operators.

It is well documented that online leak and theft detection systems must find a balance between sensitivity and false alarms. Some leak detection systems can detect leaks as small as 0.5% of nominal flow-rate without the issue of false alarms. However, this becomes an issue as most theft events are less than 0.3% of the nominal flow-rate. The capability to analyse the data offline has allowed the location and detection of theft to within five meters for thefts as small as 0.1% of the nominal flow-rate in static and running conditions.

Combining a detected theft service with a single or multiple online leak detection system allows for a more reliable leak detection system with the ability to effectively deal with all types of theft events. In the last two years, this combination of negative pressure wave, statistical volume balance and offline analysis has enabled one supplier to successfully detect and locate over 300 tapping points for its clients.

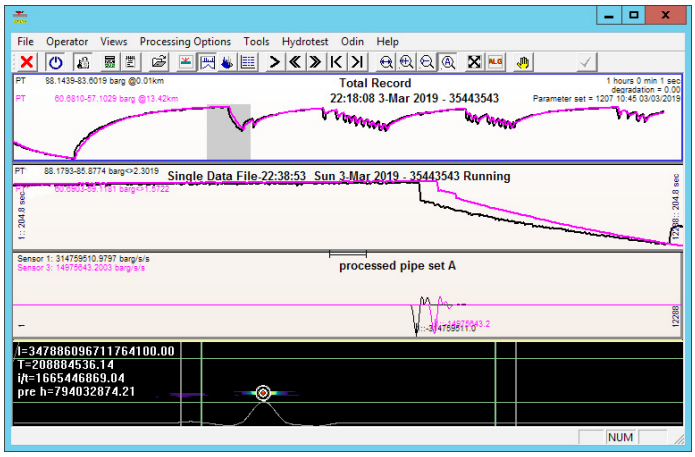


Figure 2: An example of a theft event generating 1.5 bar pressure drop

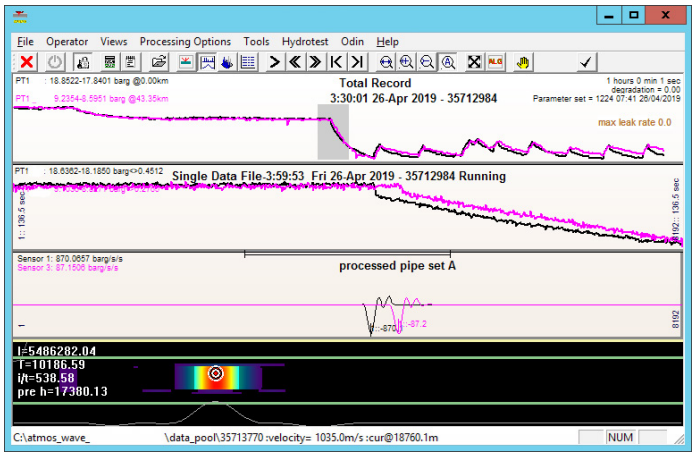


Figure 3: An example of a theft event generating 0.4 bar pressure drop only

Figure 4: Relating to the statistical volume balance section