A *RESILIENT* MONITORING STRATEGY

Kaidy Kho, Vice President - Business Development (Sales), Atmos International, UK, emphasises the importance of a single-ended leak detection for tanker loading and unloading pipelines, to ensure a resilient monitoring strategy for challenging offshore environments.

Offshore tanker loading and unloading pipelines are a vital link in the global energy supply chain. They operate in some of the harshest and least forgiving environments, often exposed to ocean swells, anchor strikes, corrosion and limited access for maintenance. When these pipelines are compromised by leaks, the consequences can be severe: environmental damage, reputational loss, costly cleanup operations, and regulatory penalties. Leak detection is therefore not simply a technical challenge but a business-critical requirement.

Conventional dual-ended leak detection systems, which rely on synchronised instrumentation at both ends of a pipeline, can be impractical in these contexts. Offshore monobuoys and single-point moorings rarely provide the necessary infrastructure, power or communications. This is where single-ended leak detection offers a resilient and practical alternative. Building on both simulated and field-proven performance, single-ended leak detection enables operators to maintain high standards of safety and compliance without the need for costly offshore instrumentation upgrades.

The case for single-ended leak detection

Tanker loading and unloading operations are inherently complex. They involve flexible subsea lines, short transfer distances and transient flow conditions as pumping starts and stops. Conventional monitoring approaches, which compare

measurements at both pipeline ends, are hindered by the absence of offshore instrumentation. This creates blind spots in leak detection, leaving operators exposed to risks.

Single-ended leak detection systems address this challenge by relying solely on measurements at the accessible end, usually located onshore or on a nearby platform. Through advanced signal processing, pressure and flow data can be analysed with sufficient resolution to identify anomalies that indicate leaks. By eliminating reliance on offshore instrumentation, single-ended leak detection provides a pathway to resilience and regulatory compliance in challenging marine environments.

Technical framework

The technical approach to single-ended leak detection builds on well-established pressure and flow monitoring principles. At its core, the system leverages high-frequency data acquisition at the onshore terminal, applying statistical and transient analysis to distinguish leaks from normal operational events.

Key elements of the framework include:

- Data acquisition: capturing flow and pressure signals with sufficient frequency to detect small deviations.
- Signal conditioning: filtering noise to account for turbulence, pump vibrations, and valve operations.
- Event detection: identifying specific signatures that indicate the onset of a leak.
- False alarm minimisation: applying thresholds and adaptive algorithms to avoid unnecessary operational interruptions.

This methodology ensures that even under highly variable conditions, single-ended leak detection maintains sensitivity while delivering reliable results.

Case study: real-world performance

One operator in Latin America implemented a leak detection solution for a short offshore to onshore diesel transfer pipeline which presented a number of technical and logistical challenges. The 1 km pipeline, partly subsea and partly onshore, was used for unloading fuel from ships to storage tanks.

The operator originally considered ship-side instrumentation to support monitoring, but this proved impractical due to vessel variability, safety restrictions, and space limitations. Instead, a single-ended system was deployed using instrumentation installed onshore, eliminating the need for offshore equipment and simplifying the project.

Despite the short length of the line and the corrosive marine environment, the solution delivered reliable results by applying negative pressure wave analysis and high-resolution data processing. This approach allowed for accurate leak detection and compliance with international best practice (such as API 1130) without requiring significant modifications to the existing infrastructure.

Key findings included:

- High sensitivity: detection of very small leaks, with a location accuracy of approximately 0.25% of pipeline length.
- Low false alarm rate: ensuring operational confidence and minimising unnecessary shutdowns.

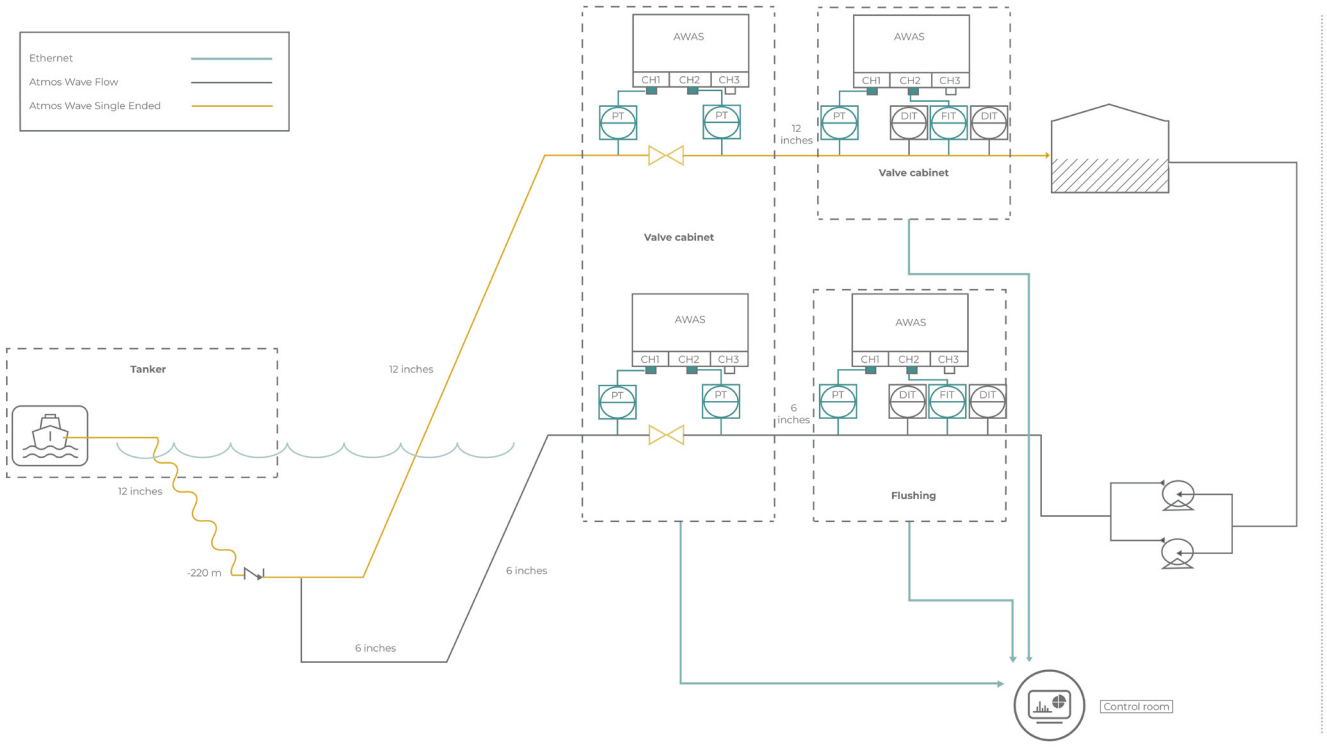

Figure 1. Atmos Wave's single-ended solution on the diesel pipeline transporting fuel from ships offshore to tanks onshore and Atmos Wave Flow on the flushing pipeline.

- Rapid implementation: the system was retrofitted without complex or costly modifications.

Operators reported increased assurance in their unloading operations, noting that the system was ready to collect data immediately and optimised their compliance processes.

Operational benefits

The adoption of single-ended leak detection brings several operational advantages. These can be grouped into safety, compliance, efficiency and cost:

- Safety: single-ended leak detection reduces the risk of undetected leaks, protecting the marine environment and ensuring public trust.
- Compliance: by meeting and often exceeding regulatory detection thresholds, operators can demonstrate due diligence.
- Efficiency: simplified infrastructure requirements reduce downtime and accelerate deployment.
- Cost-effectiveness: single-ended leak detection avoids the expense of installing and maintaining offshore instrumentation providing long-term savings.

Taken together, these benefits highlight single-ended leak detection as a pragmatic solution that balances technical performance with commercial realities.

Wider implications for the industry

Single-ended leak detection aligns with the industry's push toward operational excellence and sustainability. By lowering the cost barrier to effective leak detection, it enables operators to extend best practices to assets that might otherwise remain vulnerable. The scalability of the approach means lessons learned in one deployment can be applied across multiple facilities, multiplying the impact.

Shaping the future of offshore pipeline safety

As offshore energy logistics evolve, the demand for resilient, practical and cost-effective monitoring strategies will only increase. Single-ended leak detection has proven itself as a credible alternative to conventional systems in challenging offshore environments. By combining advanced signal processing with pragmatic infrastructure use, it delivers safety, compliance and efficiency without the need for extensive offshore modifications.

For operators facing the dual challenge of maintaining pipeline integrity and controlling costs, single-ended leak detection offers a compelling solution. Its successful deployment in real-world case studies provides confidence that this approach can bridge the gap between technical aspiration and operational reality. As the industry looks to the future, single-ended leak detection is well placed to play a central role in advancing marine logistics safety.