

Background:

Large hydrocarbon fluid pipeline leaks are usually detected by a SCADA system that controls and monitors the pipeline. As a first line of defense, SCADA systems use flow or pressure deviation calculations or rate of change monitoring on flow and pressure measurements and alarm a sudden change in flow or pressure as a possible leak.

Smaller leaks are harder to detect and may not necessarily generate an analog deviation or rate of change alarm. A Computational Pipeline Monitoring (CPM) system is used in combination with a SCADA system to detect these leaks.

- API 1130:

API 1130 document describes various detection methods used in the industry. It also describes other related technical information, operational recommendations, training, documentation and testing related to CPM systems.

Selecting a system:

API's Publ 1149 approach can be used to establish theoretical leak detection sensitivity based on instrument inaccuracies. For a running pipeline that is controlled through a SCADA system, real-time data can be collected for various leak scenarios and modeled off-line using various leak detection systems. Publ 1155 approach can then be used to evaluate various leak detection systems against each other and calculated Publ 1149 benchmark. A vendor and leak detection product can subsequently be selected based on the findings.

- Publ 1149:

Publ 1149 deals with the uncertainties of various elements of the pipeline and how it affects leak detectability. Publ 1149 uses a simple mass balance technique to come up with a theoretical leak detection limit taking into account instrument inaccuracies and physical characteristics of a pipeline.

Leak detection sensitivity \geq Steady state uncertainty + Transient uncertainty

Where Steady state uncertainty is uncertainty in flow caused by flow, temperature and pressure uncertainties and Transient uncertainty being the specific uncertainty caused by transient conditions of a line.

- Publ 1149 equation:

$$\frac{Q_{\text{leak rate}}}{Q_{\text{pipeline flowrate}}} \geq \sqrt{\left(\text{Flow}_{\text{in}} \text{ Uncertainty}^2 + \text{Flow}_{\text{out}} \text{ Uncertainty}^2\right) + \left(\frac{\text{Linefill Uncertainty}}{\Delta\text{Time} \times \text{Flowrate}}\right)^2}$$

- Publ 1155:

Publ 1155 is a defined methodology for evaluating leak detection systems for a particular pipeline. A vendor's model is used to model a specific pipeline, real-time data collected from the SCADA for various leak scenarios is then run against that model, results are evaluated against Publ 1149 expectations and compared to results from other vendors. Accurate data collection for various scenarios may require leak simulations by discharging fluid from the pipeline at various non-telemetered locations and rates (into a stationary tank or tanker truck).

Publ 1149 results and other performance metrics such as Reliability, Sensitivity, Accuracy and Robustness can then be used to rate various products against each other. While comparing various products using the performance metrics, specific attention should be paid to overall quality, minimal false alarms, ease of configuration, use and maintenance, commercial stability of vendor, availability of long term support, practicality of the overall system, cost and technology used.

Project check list for vendor selection phase:

Tasks	Primary Responsibility	Secondary Responsibility
Select one or two moderately complex "pipelines of interest," which are critical to Client.	Client	Consultant
Collect actual operating data including flow, pressure, temperature and petroleum product properties	Client	Consultant
Analyze hydraulic and instrument behaviors including accuracies.	Consultant	Client
Determine expected leak detection sensitivity using the collected data based on the API 1149 procedure.	Consultant	Client
Develop an expected leak detection performance including sensitivity, false alarm rate, detection time, usability, etc.	Consultant	Client
Collect real-time operating data with simulated leak test data	Client	Consultant
Supply the collected data with the other required data to vendors for the API 1155 study.	Consultant	Client
Evaluate the vendors' results comparing the leak detection performance.	Consultant	Client
Select a vendor with the best performance based on the vendors' results keeping in mind API Publ 1155 methodology.	Consultant	Client
Develop realistic leak detection performance requirements for all pipelines.	Consultant	Vendor Client
Draft a Statement of Work (SOW) for the project with the expected leak detection performance, making it legally binding for the vendor to deliver the leak detection system.	Consultant	Vendor Client

Selecting a pipeline leak detection system, a practical approach



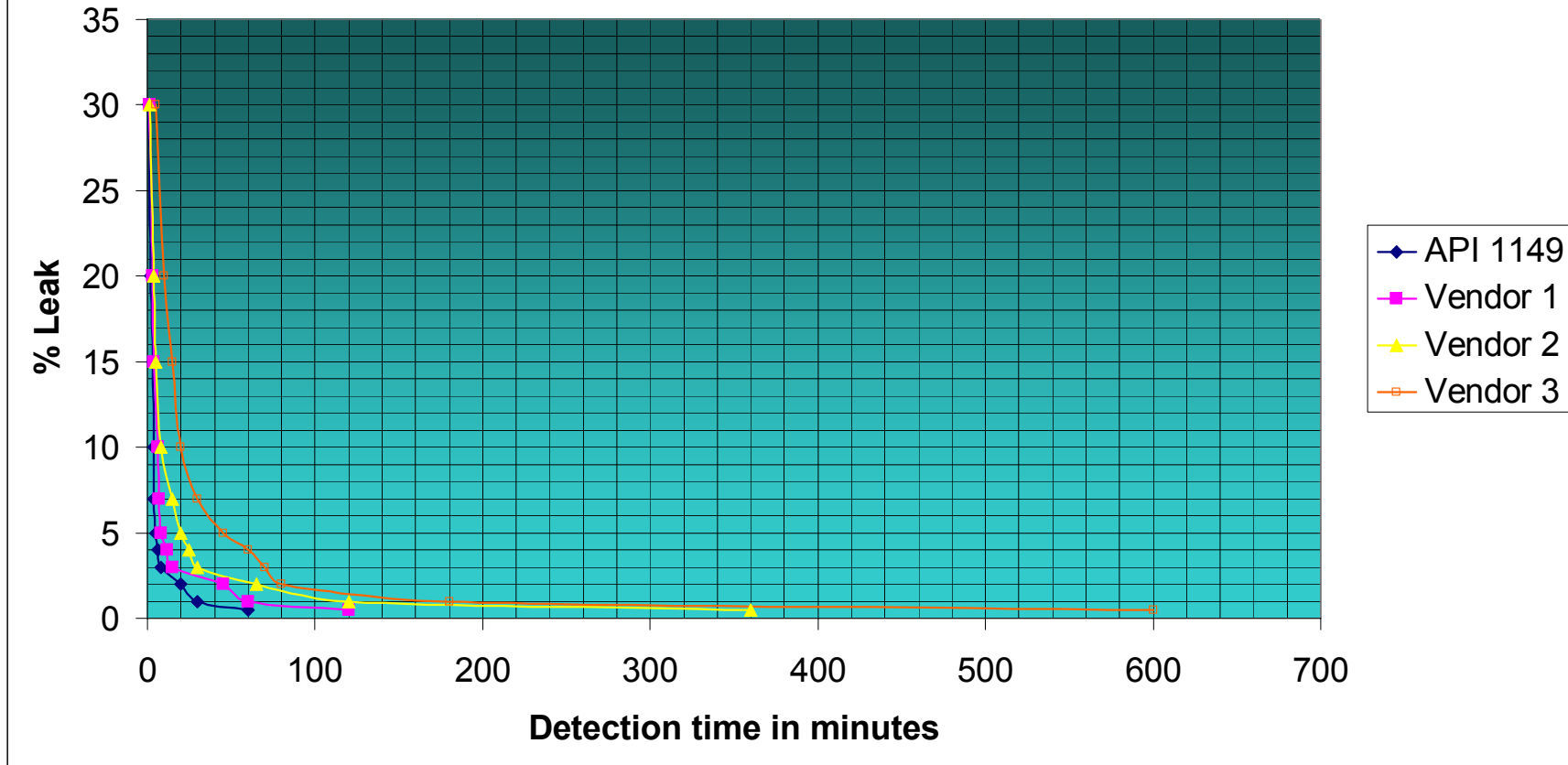
Once the system is installed and fine-tuned, leak detection sensitivity could be evaluated against sensitivity expectations of the SOW before project acceptance.

Evaluation example:

The following table and graph is a fictitious example comparing leak detection sensitivity results of Publ 1149 calculations against three different vendor models for simulated leaks between 0.5% through 30%.

% leak	API 1149	Vendor 1	Vendor 2	Vendor 3
0.5	60	120	360	600
1	30	60	120	180
2	20	45	65	80
3	8	15	30	70
4	6	12	25	60
5	5	8	20	45
7	4	7	15	30
10	3.5	6	8	20
15	3	4	5	15
20	2	3	4	10
30	0.5	1.2	1.5	5

Leak detection sensitivity example
Comparing API 1149 benchmark vs vendor models



Brief review of some CPM vendors

The following list is representative of the major companies active in this market, but is not necessarily complete

Consipio is able to assist in various activities including: specification development, vendor searches, sensitivity studies, design, development, configuration, installation, deployment, maintenance and support.

Atmos International:

- Product: ATMOS Pipe
- Statistical analysis of imbalance (including line pack). = Method 8 in Appendix C in API 1130.
- Not as dependent as some other methods on instrument accuracy. Not dependent on line composition information (uses composite fluid property).
- Based in Manchester UK. Founded by ethnically Chinese lady, resident in UK. Language advantages for Asian projects. Office in Beijing.
- Projects in 28 countries. Major projects in Caspian area, Africa (ExxonMobil), others. Customers include Esso UK, BP, Shell, ConocoPhillips.
- Offers batch+scraper tracking/scheduling and leak location estimation.

Colt Engineering:

- Product: Lineguard
- Location: Calgary, Canada
- Learns the normal operating characteristics of a pipeline over time. Compares real measurements to modeled predictions.
- Real-Time Transient Model (Method 5 of API)
- Customer list not available at time of writing. Includes Imperial Oil (IOL, ExxonMobil affiliate)

CriticalControl Solutions Inc.(CCS):

- CCS purchased Simulations of TCEnet
- Product name: PipeWorks
- Method 5 (Real Time Transient Model).
- Provides batch tracking, DRA and scraper tracking, pressure, density and temperature profiles. Estimates leak location.
- Based in Calgary, Canada
- US customers: ExxonMobil, Buckeye, Explorer, Sunoco
- Many international customers: IOL (ExxonMobil affiliate in Canada), Petrobras (Brazil), VSPL (India)

EFA Technologies, Inc.:

- Product: LeakNet
- Location: Sacramento, California
- Two methods: PPA (Pressure Point Analysis) and MassPack
- PPA detects signature of Expansion Wave that accompanies a leak
- Option to detect leak location
- Used on North Slope of Alaska
- Many big-name customers: ConocoPhillips, Shell, BP. International customers: Bahrain Petroleum, Chinese Petroleum Corp., .
- Batch/scrapper training available, plus training simulator.

Energy Solutions Int. (ESI):

- Products: PipelineManager/PAS (leak detection), PipelineTransporter (batch tracking/scheduling)
- ESI has purchased well-known companies and acquired their products: LicConsult (LicEnergy), Modisette and SSI.
 - 300 installed systems
- Suite of solutions offers almost all of the API 1130 Appendix C methods using models of varying complexity.
- Predictive model available.
- Many big international customers. e.g. BP, China National Petroleum Co., ConocoPhillips,
- Worldwide offices include Calgary, Houston, Brussels

Enviropipe:

- Based in Lake Jackson, Texas
- Customers: BP, LINK Energy, Valero, Kinder Morgan
- Method: Volume balance + line pack
- Reputation for simple but robust model
- Graphic screens built automatically by application based on pipeline config.
- Batch/scrapper tracking available. Can estimate leak location.

Telvent:

- Two Leak Detection products:
- Liquids Management System (API method 4)
- SimSuite (API method 5)
- Owned by Spanish company Abengoa. Based in Calgary, Canada (acquisition of Valmet/Metso).
- The two products are priced differently. LMS is very widely used. SimSuite is a relatively new acquisition, coming from the nuclear waste water monitoring industry (high accuracy but may or may not be practically appropriate for petroleum pipelines).
- Both products are already well integrated with Telvent's SCADA system OASys DNA. (No new SCADA interface required - can be major advantage.)
- SimSuite estimates leak location. LMS does not.
- Provides batch tracking, DRA and scraper tracking, pressure, density and temperature profiles.
- Large market penetration. Only vendor in survey to offer full SCADA system. 70% of liquid pipelines in North America use Telvent's SCADA systems.
- Many international customers including PDVSA, Saudi Aramco, many in China (e.g. PetroChina, China FuShun, China Petroleum Tech