



***Model Behaviour***  
***The use of Model Based Pipeline Leak Detection***

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## **INTRODUCTION**

Environmental protection and the prudent stewardship of a company's assets are two of the hot button topics confronting the oil and gas industry today. Nowhere is this more true than in the energy pipeline segment. In order to meet the ever expanding environment, health and safety challenges, pipeline companies are turning to model based Leak Detection Systems (LDS) as a low cost, effective means to monitor and safeguard their operations.

There is no 'one size fits all' when it comes to LDS, each pipeline operation is unique. Therefore, it is important to the ultimate success of an LDS project to consider carefully the various leak detection methods available and to select the one best suited to the specific pipeline under consideration. Each LDS method has its strengths and areas of improvement and it often takes a combination of methods to yield the optimum results.

## **MODEL BASED APPROACH**

Energy Solutions International, Inc. is a pioneer in the pipeline software business with nearly 30 years of experience in model based leak detection systems. The primary benefit of model based LDS is the high percentage of system availability. These systems are able to remain active during rigorous operational transients as well as during varying degrees of data outage. Moreover, model based LDS requires little in the way of additional instrumentation or telemetry hardware for the typical pipeline installation to achieve acceptable minimum performance (defined as sensitivity, accuracy and robustness).

## **LEAK DETECTION METHODS**

In order to meet the demands for detecting a wide range of leak sizes, several leak detection methods should be included in an LDS. Energy Solutions' PipelineManager application is based on a fully transient hydraulic and thermodynamic model, capable of accurately simulating the behaviour of specific pipeline operations. By using different input to drive different methods, several distinct leak responses are provided. By combining and evaluating each of these responses, the application is capable of detecting leak sizes ranging from very small pinhole sized leaks to full pipeline ruptures.

For instance, while flow meter based techniques generally offer excellent LDS performance (including estimates of leak location), performance may degrade during an extended data outage. Also, once good data feed is restored it will typically take a period of time before leak detection performance again reaches optimum status, owing to the missing information during the outage. The volume accumulator based technique is typically used for detecting smaller leaks over longer periods and recovers more quickly from any data outage, as less historical information will be lost during data outages. This is because volume accumulators are restored to full functionality as soon as communication is restored, while flow meters only

provide instantaneous readings with no means to integrate data missing during the outage. Therefore, it is essential that the LDS utilise all available techniques including both flow meter readings and volume accumulators.

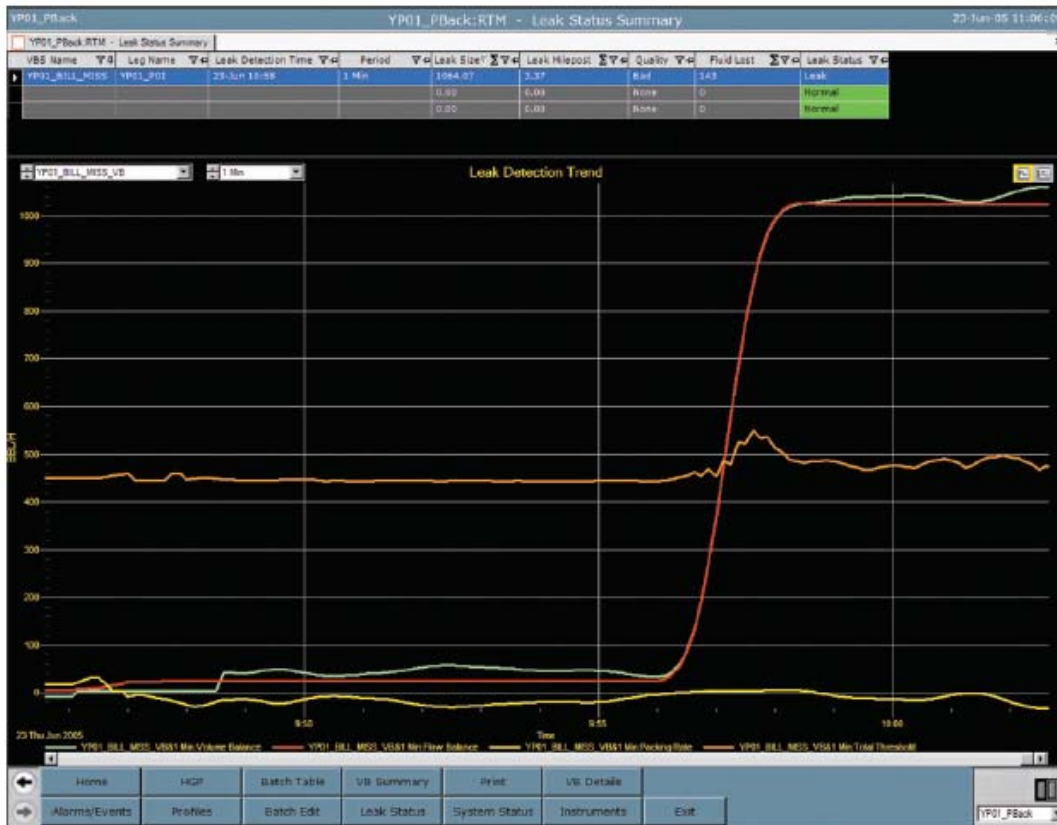
## **ENSURING LDS PERFORMANCE**

Accurate modelling of all relevant pipeline operations is critical to LDS performance. To ensure accurate pipeline simulation, various parameters are tuned based on observation of model responses and actual values obtained from instrumentation. These parameters include both physical pipeline properties and product properties. Part of the tuning process may be accomplished prior to site installation utilising a historical operational data set. The more historical data that are made available during the system configuration phase, the simpler and more cost effective it is to complete final installation and commissioning. Using historical operational data also helps ensure that the final system is capable of operating with minimum false leak alarms during representative operations. Finally, thorough and rigorous tuning during the installation and testing phase helps reduce ongoing system maintenance and support.

To help make an LDS operational and efficient, ENERGY SOLUTIONS uses a Threshold Optimizer. This tool is capable of analysing large amounts of historical pipeline data. Based on these data, it determines the optimum settings for the alarm thresholds used in the system. This approach ensures that a leak detection system is operational with optimum performance in as little time as possible.

## **DIAGNOSTIC TOOLS**

Once the LDS has been installed and commissioned, it is very important that the pipeline operators know how to use the system and can react properly to system output. A training course combined with specific operator procedures (including a check list or flow chart) will help guide the operator should a leak occur. Energy Solutions' applications include tools to help an operator diagnose a potential problem, including trends and profiles of relevant data. One specific and very helpful diagnostic tool is the capability of analysing the individual responses that make up a final leak response. For example, the leak response based on a model compensated line balance technique is defined as the flow imbalance minus the packing rate. When an operator trends the leak response the flow imbalance and the packing rate are shown as well (Figure 1). This assists the operator by diagnosing whether the response is triggered by one or more instrumentation problems or represents a true leak incident. Diagnostic tools such as these help avoid costly pipeline shutdown and interruption of planned operations.



**Figure 1. Leak response analysis.**

**LATEST INNOVATIONS**

Energy Solutions is currently in the process of implementing several large scale LDS and batch tracking projects worldwide. Of particular note is its most current project for a major North America liquids pipeline company. This project involves the installation of its latest release, PipelineManager application, which includes the newest Graphical User Interface called VisualPipeline(TM). The principal goal for this project and the use of the new user interface is to present the wealth of data regarding the operational status of the pipeline to the control room operator in a quick and intuitive layout, while hiding or minimising all non essential information. However, certain users, pipeline engineers and control room supervisors, for example, may require the complete data set be made available all on one screen. Therefore, the application must be able to be run in two separate modes - browser mode and engineering mode - to meet the specific informational requirements of the intended user.

**BROWSER MODE**

The browser mode is designed primarily for control room operators and other users where easy to see, quick access to operational data and pipeline status is a top priority. Only one screen may be visible at any time

and navigation between screens is effectuated via dedicated buttons at the bottom of the screen or by clicking on the back and forward buttons. Individual users may define their most utilised screen as their home page for easy return. In the browser mode it is possible to view batch tracking, leak detection status and the hydraulic gradient profile all on one screen (Figure 2) and the user can zoom in and out as required. Additional details will automatically appear if the selected zoom level permits. By double clicking on the hydraulic gradient profile a dialogue box appears revealing detailed LDS, batch tracking and other important information related to the selected position on the pipeline (pressure, product, density etc.). From here or any point along the pipeline the operator may then navigate directly to the nearest upstream and downstream 'points of interest' (defined as mainline valves, pump stations, change of pipe properties etc.) and review the operational status of the line and/or secure detailed information related to that location.



**Figure 2. Batch tracking, leak detection and hydraulic gradient profile.**

#### ENGINEERING MODE

The engineering mode is intended for advanced users such as engineers and supervisors, where flexibility and access to the complete set of data is required. In this mode, several windows can be open at the same time and each window may be sized as required. It is also possible to view and modify any data point within the database via a data tree. In this mode it is possible to define pipeline views (e.g. sections of a larger

network) and save these views for future use. The user can define profiles and trends of both content and layout (e.g. show a pressure and flow time trend in a specific format) and save the final result as a template that can be applied easily to any similar object in the future.

## **OTHER APPLICATIONS**

In addition to LDS functionality, transient model based systems such as PipelineManager offer pipeline operators a host of real time information related to the current hydraulic state of the pipeline such as batch or product tracking and scraper tracking. Model based applications have the capability of providing look ahead and predictive analysis, including 'what if' analysis, which can simulate certain operational changes prior to actually executing them live on the pipeline. Often such analysis involves detailed modelling of all relevant equipment within each station (i.e. pumps/compressors, heaters/coolers, tanks etc.). Model based systems may also be used for operator training and qualification. Energy Solutions offers a flight simulator style Training Simulator that may be configured with true SCADA 'look and feel' and includes automated trainee evaluation and scoring.

## **CONCLUSIONS**

The main drivers for installing LDS applications are typically:

- To demonstrate prudent operations to all stakeholders.
- To react appropriately to potential or real pipeline leaks.
- To comply with all applicable regulations.

Pipeline operators must carefully select the vendor with the LDS most suited to its pipeline operations. A transient hydraulic and thermodynamic model offers the most flexible and robust LDS for energy pipeline operations. In addition, transient hydraulic models are the platform for other critical operational and business applications such as batch tracking and predictive modelling, which serve further to cement the relevance and cost effectiveness of model based leak detection systems.