Asel-Tech

ILDS - AN INNOVATIVE APPROACH FOR PIPELINE LEAK DETECTION

Introduction

Leaks in pipelines always imply in material losses and in many cases the incident can turn into a critical event, particularly when the transported fluid is dangerous to life or environment. There are always chances of accident occurrence, even with attention given to its prevention. For this reason, leak detection systems (LDS) play an important role in any pipeline integrity program.
LDS are specially designed tools that help operators to quickly identify and react to a spill. This systems continuously monitor the pipeline operation and alarm deviations from normal condition that can be associated with a leak. Response time, sensitivity, reliability, accuracy and robustness are common performance parameters used to evaluate LDS. Applicability to a wide range of fluids and scenarios is also a highly desirable characteristic.

Asel-Tech's new ILDS (Integrated Leak Detection System) has been designed around all the above mentioned characteristics, based on two different methodologies for detecting leaks: Negative Pressure Wave and Mass Balance. The concept is clearly recommended in API RP 1130. The innovative approach relies on the synergy between the two applied methodologies that have complementary features and characteristics strategically combined on the ILDS.
This combination allows unique features and improves the overall system performance by exchanging information and updating parameters in real time. Among the main benefits we could mention fast response time, accurate leak location, precise time stamp (GPS sinc), leak rate estimation, spilled volume quantification, graphic trends, cross checking alarm validation and others, resulting in higher levels of sensitivity, robustness and reliability. This rich set of features is not available in any other leak detection pack.

Negative Pressure Wave Methodology

The negative pressure wave methodology, as presented in API1130, also known as sonic or acoustic, works based on the identification of the hydraulic transients associated with leaks onset. The generated transients propagate as wave fronts through the fluid at sound speed, in both directions. The wave fronts are guided by the pipeline walls and can travel over very long distances. Special transducers installed at both ends of the monitored section measure the dynamic pressure converting it to an electrical signal that is read and analyzed by the Field Processing Units (FPU).

The wave front detection time at each sensor is registered and, since the propagation velocity is known for each fluid, the leak location can be easily calculated based on the registered arrival time. Time accuracy is assured by a GPS interface, which keeps all FPUs clocks precisely synchronized. Presence of back-ground noise and operational events, such as those originated by pump start/stop or valve opening /closing, require several different filtering techniques to properly extract and identify the leak signature. Effective filtering associated with multilayer detecting algorithms are the key to assure 100% of pipeline coverage with no any mute or silent zones. A few examples of applied filters are: correlation, band-pass, phase sequence, envelope follower, implemented both in hardware and software, plus innovative techniques based on artificial neural network (ANN). This complex set of processing technologies grants to ILDS its unique combination of features and characteristics.

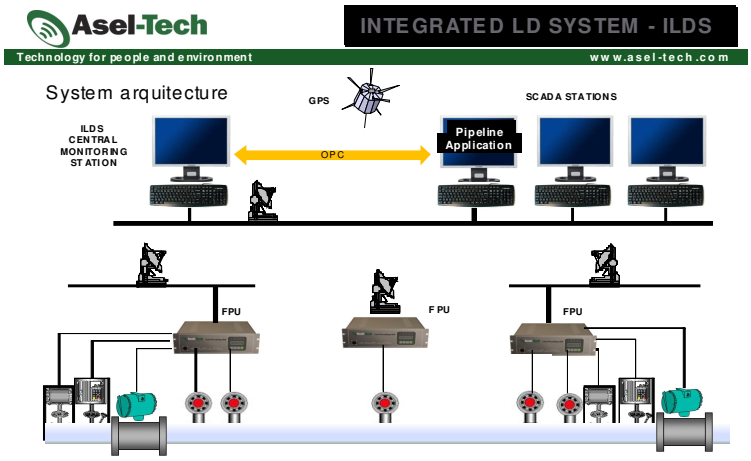
Mass Balance Methodology

This methodology infers that a leak may exist based on deviations in the mass balance that results from product release. The detection consists in the analysis of the difference between the outlet and inlet flow also considering the variations in the on-line calculated line-pack. As inputs, the model uses measurements taken at both ends of the monitored section, (flow, temperature, pressure, density), and also the pipeline and fluid parameters and specifications configured in the system. Computational Fluid Dynamics (CFD) algorithms based on real-time flow modeling runs cyclically on the Central Monitoring Station, allowing on-line calculation of accurate flow profiles along the pipeline, including transient regimens. The outputs of CFD algorithms are fundamental for correct line pack calculation. The line pack variation can then be plotted against the in-out mass differences, producing characteristic curves that represent the behavior of the pipeline flow making possible trend analyses even before a leak alarm generation.

Alarm Validation and Trend Analysis

Considering the complementary characteristics of the acoustic and mass balance technologies, based on data provided by both detecting techniques it is possible to have a better and wider evaluation of the pipeline operation scenario. This is a unique advantage of the ILDS not featured by any other leak detection pack in the market.
The alarm validation and trend analysis module comprises special algorithms based on artificial neural networks (ANN) improving the overall system ability to distinguish real leaks from the various operational events such as pump start/stop, reducing dramatically the false-alarm rate.
Before the final alarm is issued for the user, the validation module cross checks the information coming from both detecting modules as well as analyzes other variables and trends. If all the conditions are coherent with a leak situation the alarm is then issued along all its related information (location, time stamp, leak rate, spilled volume, trends, etc).

System Architecture



The ILDS architecture and its main components are shown in the figure aside. The Negative Pressure Wave methodology comprises Acoustic Sensors (FSS), Field Processing Units (FPU) and Central Monitoring Station (CMS). The Mass Balance requires transmitters at both ends of the pipeline (pressure, temperature, flow and density) also sharing the Central Monitoring Station (CMS).
Data communication is based on Modbus protocol and can be implemented using different links such as Ethernet, radio, optical fiber, satellite, etc. Integration between ILDS and pipeline customer SCADA is facilitated by an OPC driver embedded in the CMS. When necessary, this integration allows collecting information from pre-existent flow measurement instruments as well as on operational events such as valve operation, pump start/stop, operational changes, etc, to be used in the mass balance and validation module.
Main user interface functions are based on off-the-shelf supervisory package (such as iFix, Intouch) according to client preferences.

ILDS summary

- ✓ Two complementary methodologies compliant to API RP 1130, Negative Pressure Wave & Mass Balance;
- ✓ Sophisticated signal processing including artificial neural networks and multi layer detection algorithms.
- ✓ Mass balance algorithms relying on Computational Fluid Dynamics (CFD) models;
- ✓ Precise line pack calculation including transient regimens;
- ✓ Cross checking alarm validation and trend analysis;
- ✓ Adaptability to different operational conditions with learning capability;
- ✓ Easy integration to SCADA using OPC and commercial supervisory packages;
- ✓ High sensitivity and fast response time;
- ✓ Location accuracy better than 2% of the monitored length;
- ✓ Detects progressive and pre-existing leaks;
- ✓ Detects leaks even with pipeline in shut-in condition;
- ✓ Complete leak report with leak location, time stamp, rate, spilled volume and graphical trends;
- ✓ Very Low false-alarm rate;
- ✓ Easy installation and set-up
- ✓ Total customer support including remote assistance;

Reference: ILDS catalogue - DT-001 Ver 2 – July/2010