Asel-Tech
Leak Detection Solutions

I-RLDS – INTEGRATED REMOTE LEAK DETECTION SYSTEM

INTRODUCTION

Leaks in liquid and gas pipelines always mean material losses. In some cases an incident can turn into a critical event, particularly when the transported fluid is dangerous to life or the environment. Operators all over the world are continuously increasing their efforts and investments towards integrity programs. To do this, they target the prevention of undesired events, in order to minimize direct costs (e.g., remediation, penalties and repairs) and indirect costs (e.g., public image and stock devaluation). However, there's always a chance that an accident will occur, no matter how much attention is given to its prevention. For this reason, leak detection systems (LDS) play an important role in integrity programs. LDS are specially designed tools that help operators to identify and react to a spill. They are in-line systems that continuously monitor and alarm deviations of some operational condition that can be associated with a leak. Speed of response, sensitivity, reliability, accuracy and robustness are common performance parameters used to differentiate these systems. Last but not least, applicability to a wide range of scenarios is a highly desirable characteristic.

Asel-Tech's new I-RLDS (Integrated Remote Leak Detection System) has been designed around all the above mentioned characteristics and most important, featuring two different methodologies to detect leaks: Negative Pressure Wave Technology and Compensated Mass (or Volume) Balance. The concept itself is not new, it is on the contrary, clearly recommended in API RP 1130. The innovative approach is more subtle in the sense that it is hidden inside its hardware and software components. In order to unveil I-RLDS's innovative nature, one needs to look into the inner layers of its components. This article briefly describes I-RLDS's principles and its architecture. Emphasizing the synergy between the two methodologies as opposed to other implementations that merely bundled two or more techniques as one package, but running as isolated subsystems. Beyond the additive and complementary nature of a dual methodology (final system inherits characteristics from each individual subsystem); a bidirectional collaborative implementation produces a synergistic improvement in overall performance.

DETECTION METHODOLOGIES

I-RLDS employs two methods to detect leak events. One method is the identification of the negative pressure wave originated by the leak. The second method, is the identification of an imbalance between inflow and outflow, compensated by the line-pack variation over a given time interval.
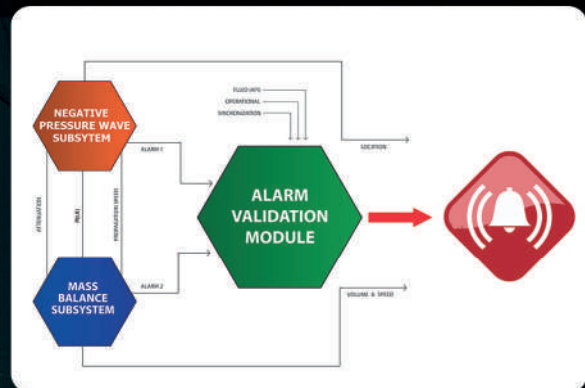
I-RLDS Block Diagram

NEGATIVE PRESSURE WAVE TECHNOLOGY (RLDS)

The RLDS technology can effectively be employed to detect leaks in pipelines that transport various types of products (liquids, gases or multiphase), and can be applied to above- ground, below-ground or subsea pipelines.

The RLDS operating principle is based on the detection of pressure transient waves caused by the onset of a pipeline leak. Unlike "Acoustic Emission" technology, Asel-Tech's system is not designed to detect the audible noise produced by leak flow, and does not detect sound in the pipeline material whether it is steel, stainless, HDPE etc.

The pressure transient waves that our system detects are caused by the sudden drop in pressure, and the immediate line re-pressurization at the location of a leak onset. This onset causes pressure oscillations in the fluid pressure and propagates as a wave signal at the speed of sound through the fluid or gas, away from the leak location in opposite directions guided by the pipeline wall.

Pressure sensors installed at opposite ends of the pipeline segment will intercept and transmit the leak signal to the corresponding Asel-Tech SRU-504 remote unit. The SRU-504 is responsible for the acquisition and signal conditioning from the pressure sensors and sending to CMS. The signals are processed by sophisticated algorithms, including Artificial Neural Network (ANN) and other specific components of leak detection module. When all the requirements that define a leak signal are confirmed, including the neural network, an alarm will be declared by the Central Monitoring Station computer (CMS).

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MASS BALANCE

This subsystem infers that a leak exists based on the mass unbalance that results from product release. The detection can roughly be described as the analysis of the behavior of line-pack variation compared to the difference in inlet and outlet flows. The model uses measurements taken at both ends of the monitored stretch (flow and temperature), pipeline and fluid specifications as well as pressure/temperature measurements at intermediate points. Computational Fluid Dynamics (CFD) algorithms based on real-time transient models (RTTM) run cyclically on the Central Monitoring Station, producing a curve representative of the behavior (signature) of the line-pack variation relative to in-out mass variation. Again, filters based on Artificial Neural Networks (ANN) qualify this signature, or its trend, as being typical of a leak or not.

The final decision is taken by the Validation Module which, in its turn, also uses information generated by the Negative Pressure Wave Subsystem to validate the event and declare a LEAK ALARM along with associated information (position, leak flow rate, duration, etc.).

The validation process and trend analysis employ special algorithms based in artificial neural networks (ANN) which allow the system to distinguish between various operational events and real leaks, reducing dramatically the false-alarm rate, a well-known issue for all LDS, specifically mass conservation methods.

In order to validate an alarm, the Validation Module performs a cross-check of the corresponding signals received from both subsystems as well as qualitative and quantitative analysis of other variables, e.g., tendency of mass variation. Once recognized and declared as a LEAK ALARM, the event is displayed to the operator along with relevant information such as the moment it started, its exact location, instantaneous leak rate and total spilled volume.

SYSTEM ARCHITECTURE

The Negative Pressure Wave System (RLDS) comprises Pressure Sensors (FSS), Remote Units (SRU) and Central Monitoring Station (CMS). The Mass Balance System comprises transmitters at both ends of the pipeline (temperature and flow) and Integrated Remote Unit (SRU-I).

I-RLDS architecture is supported by a communication network, like radio, optical fiber, cable, and landline, mobile (3G/4G). The protocol is Ethernet. Integration between I-RLDS and pipeline SCADA is facilitated by an OPC driver embedded in CMS.
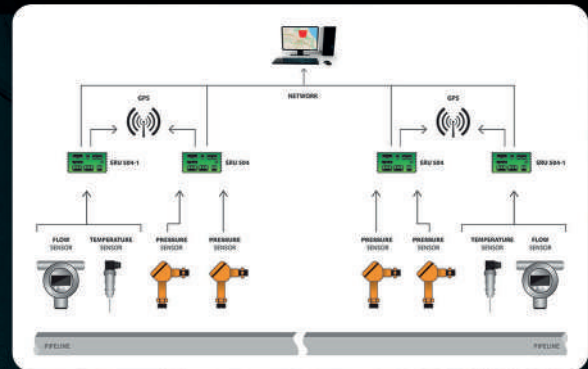
I-RLDS Architecture

Moreover, all user interface functions are based on off-the-shelf supervisory package (such as iFix, Intouch, Elipse) according to client preferences. Direct integration of servers, I-RLDS and SCADA, allows information about operational events (valve operation, pump start/stop, operational changes, etc.) to be used in the validation module, improving robustness and reliability of the I-RLDS decision algorithm.

CONCLUSION

I-RLDS dual methodology and innovative implementation allow fast leak detection, precise location and accurate quantification of product spilled, featuring the following characteristics:

- Two complementary methodologies as recommended in API RP 1130; ✓ Mass balance algorithms relying on Computational Fluid Dynamics (CFD) models;

- Low false-alarm rate due to pattern recognition based on artificial neural networks techniques;

- Adaptability to different operational conditions and self-learning ability;

- Easy integration with SCADA or DCS using OPC protocol and commercial supervisory packages;

- Fast detection with alarming in the range of 60 seconds or better;

- Sensitivity better than 1% of the nominal flow;

- Location better than 2% of the monitored length;

- Detects progressive and pre-existing leaks;

- Leak detection even with no flow (pipeline in shut-in condition);