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Pipeline Leak and Impact Detection System - PipeLIDS – Monitoring Product Dedicated to Onshore Pipelines

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Abstract

Onshore pipelines may be subjected to third party damage (civil works), corrosion leaks, mechanical issues (valve or pumps failures), land movements or (in extreme cases) theft of the product. These threats may lead to leaks or even more dramatic explosions. The impact on human life and the environment can be significant. The pipeline operator's public image can be damaged with non-negligible economic or political consequences.

PipeLIDS has been developed to minimize the consequences of leaks from onshore pipelines. It uses acoustic technology for detection of noise generated by impacts or leaks. This noise propagates in both directions over long distances inside the pipe. Intrusive acoustic sensors are installed regularly on the pipeline (every ten kilometers) to detect this noise. Each sensor is connected to an intelligent beacon with GPS synchronization. By measuring the sound wave's amplitude and phase time shift and analyzing the acoustic signature, PipeLIDS detects the origin and location of the event and raises an alarm.

This paper presents latest technical improvements implemented on the PipeLIDS as installed on the latest SPSE Fos-sur-Mer (France) diesel pipeline for permanent survey. Acoustic sensors have been redesigned for better reliability. Software was reviewed and updated to give more efficient data processing, detecting and locating any accidental events within few minutes while being able to eliminate false alarms. Finally, very good performances of the system is demonstrated as well as its simplicity in terms of installation.

Introduction

Pipeline operators need to anticipate and prevent possible accidents such as undeclared civils works around their assets, or corrosion weakness in old installations, that could generate fluid leaks. This may be particularly important in remote areas, where it may be difficult to identify and locate threats to the pipeline.

To answer to these issues, Cybernetix (a Technip company) has developed the **L**eak and **I**mpact **D**etection **S**ystem, the Pipe**LIDS**, which provides a simple to install and operate system, for onshore pipeline monitoring. The system uses acoustic technology to listen to the noise inside the pipeline. This is achieved with hydrophone sensors installed regularly along the pipeline, typically every 10 km.

Different trials were made for several companies to prove the capability to detect impacts simulated with a pendulum system and leaks simulated by valve opening and discharge of product into tanks. The capability of PipeLIDS was proven and ready for installation to survey critical pipelines.

Several PipeLIDS systems have been installed on different pipelines transporting different contents such as natural gas, ethylene liquid, diesel or gasoline. PipeLIDS has been supplied to different major companies, such as “Societe Pipeline Sud Europeen” (SPSE), for permanent survey of long pipelines (a few hundreds of kilometers) and point to point pipelines (a few kilometers from refinery to storage).

Because of its high sensitivity the major difficulty encountered was the limitation of false alarms. It is well known that the best way to kill a new system is to generate a lot of false alarms, after a while the operators in their control room disable the alarm display until the day when the true alarm arrives and they cannot see it.

The patented algorithm used by PipeLIDS has been improved to limit false alarms and to increase the level of confidence into the system.

After several tests, different ways for improving the reliability of the system were defined. First of all the equipment itself and primarily the sensors were ruggedized to avoid being weak points on the host pipeline fittings where they are installed. This ensures good availability, and reduces maintenance operations.

Secondly, the algorithms themselves have been improved to reduce the amount of false alarms, to increase the sensitivity, and improve the discrimination and classification of the event.

The improvements made to the system give the operators a high level of confidence in using the PipeLIDS system.

Leak and shock acoustic detection principle

Any leak generates a noise source. The amplitude and frequency spectrum depend on the fluid type, the leak flow size and geometry.

Leak noise propagates in the fluid in the pipeline. The noise can propagate over a long distance in buried, non-buried or submerged pipelines. The noise attenuation versus distance from the leak depends on the fluid used, the pipeline type and its geometry, its environment and the frequency spectrum of the leak itself.

At any point of the pipeline, the leak noise creates a pressure fluctuation, which can be measured by specific acoustic sensors installed on the pipeline.

With an appropriate data processing technique, the noise radiated by the leak is extracted from the global ambient noise in the pipeline.

Accurate leak location is possible by installing two sensors located at each end of a pipeline segment to be monitored.

The detection and location of shocks is similar. An unexpected event such as hammer, anchor, excavator, drill, fire gun shock on the pipeline, explosion or ground movement creates an impact noise source. The noise propagates along the pipeline and is remotely detected and located.

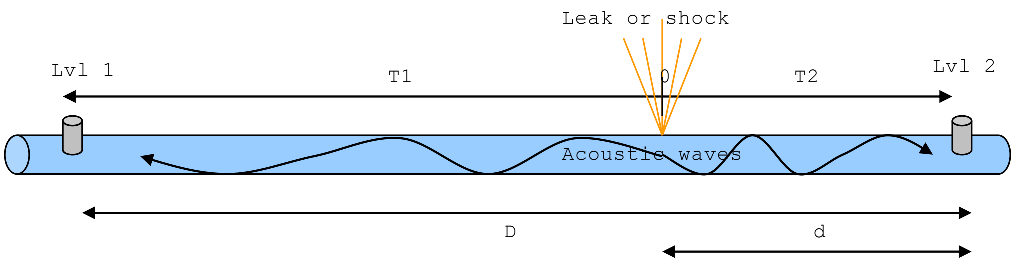
The shock is easily identified as it is a very energetic and short pulse. Its amplitude and length depends on the type of shock itself. Shocks and leaks are easily distinguishable, a shock is transient event, while a leak can also occur suddenly but is then continuous.

To locate leaks and shocks, the system must be set-up with input parameters such as accurate distances between sensors and sound speed in the pipeline (measured or calculated).

Locating leaks or impacts allows the operator to send a team on site at the selected zone to protect and repair the pipeline. The location output is the distance between the leak or the shock and the location of the sensors.

By determining the velocity of sound propagating inside the pipeline and using the exact distance between the sensors, the leak or shock position can be accurately computed with the following formula:

$$d = \frac{D - Vt}{2}$$



Equation 1: Event localization

Where: d: distance of leak from sensor
D: overall distance between sensors
V: sound velocity inside the pipeline
t: transit time difference for leak noise to reach sensors = T2-T1

By determining the acoustic attenuation of sound in the pipeline and using the sound magnitude measured by each sensor in case of leak or shock, the event source magnitude can be computed using the following formula:

$$Attenuation = \frac{20 * \log\left(\frac{Lvl1}{Lvl2}\right)}{D - 2 * d}$$

Equation 2: Sound attenuation

Where Lvl 1 = Event Magnitude level on point 1, Lvl 2 = Event Magnitude level on point 2,

Acoustic system description

The PipeLIDS system has been developed by Cybernetix since 2005. The system uses intrusive acoustic sensors (APS30) installed regularly on the pipeline, typically every 10 km. Each sensor is connected to a local intelligent beacon, called Remote Detection Unit (RDU), which may be mobile or permanent. The beacon continuously analyses the acoustic noise recorded by the sensors, via patented decision-making algorithms, to confirm, localize and transmit alarms directly to the operator.

Alarms are quickly and directly sent through the chosen communication network (SCADA, GSM, Ethernet, custom), either by SMS directly sent to mobile phones, and/or on a control room map display showing all surveyed pipelines and detected events. A typical architecture is shown on **Fig. 1**.

The Leak Impact Software Application (LISA) display is able to inform about the type of event, its time, magnitude and its location, thus leading to a quick and efficient intervention with optimal risk control, if needed.

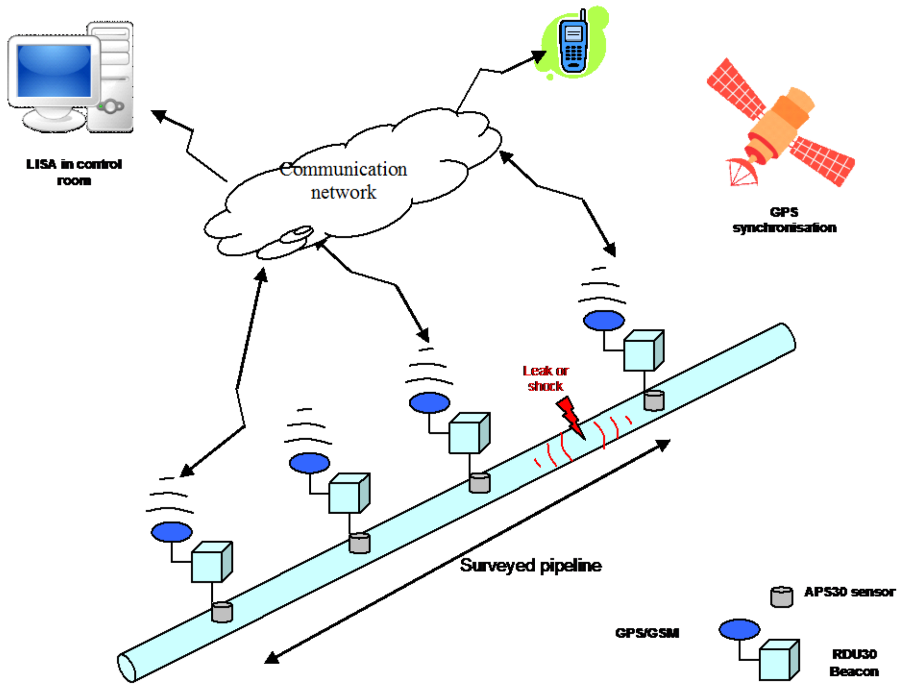


Fig. 1: Typical PipeLIDS architecture

The APS30 hydrophone sensor directly measures the acoustic noise fluctuation in the pipeline. Each hydrophone must be installed on a fitting equipped with a ball valve to enable mounting and dismantling of the sensor. This Acoustic Pressure Sensor (APS) is ATEX certified, and very sensitive (0.3mV/Pa before amplification). It is a reliable sensor which does not require any particular maintenance.

The RDU30 intelligent module collects the acoustic signal from the sensor, then analyzes the spectral response to detect abnormal signatures, confirms alarms and communicates with its neighbors' RDUs and operators and/or the LISA display.

The acoustic signal from the sensor is acquired in real time with high sample frequency. This signal is processed into a spectrum signal for analysis and better noise extraction. Processed signals are then compared to auto-adaptable thresholds. Detections are triggered locally according to the shape, the duration and the energy of the detected events. "Leak detections" or "Impact detections" are confirmed according to the event duration and the spectrum content. These detections are then sent over the pipeline communication to other RDUs to confirm alarms and locate the damage.

Very accurate timing of all detected events is possible by using the GPS integrated in each RDU. The satellite time provided by the GPS is universal and accurate to the millisecond. All points on the pipeline are synchronized with this precision. All RDU systems communicate together by using pipeline communication network capabilities, including wireless GSM or hardwire TCP/IP, SCADA or customized systems.

In case of impact or leak event detection, the closest RDU analyzes its own detection and the detection received from the other RDUs. The system then compares the event acoustics triggered signatures.

Events should be consistent regarding:

- Sound velocity (time shift between the triggered signatures);
- Magnitude attenuation;
- Frequency content;

In case of time and level consistencies the RDU confirms the impact or leak detection and locate the event.

The location accuracy depends on:

- The accurate time difference between detections on boundary RDUs (based on GPS time);
- Knowledge of the sound speed in the fluid, which can be calculated, depending on the fluid pressure and temperature;
- Knowledge of the distance between two sensors;

The RDU30 is made of ruggedized material which is compliant with extreme Industrial Certifications and Ratings: IP65, -40 to +70 °C operating temperature, International safety, Electromagnetic compatibility (EMC), and environmental certifications. However the RDU beacon is not ATEX certified and should be installed in a safe area, with a maximum distance of 300 m from the sensor (due to the electrical limitation). Typical PipeLIDS components and their connection are presented in **Fig. 2**.

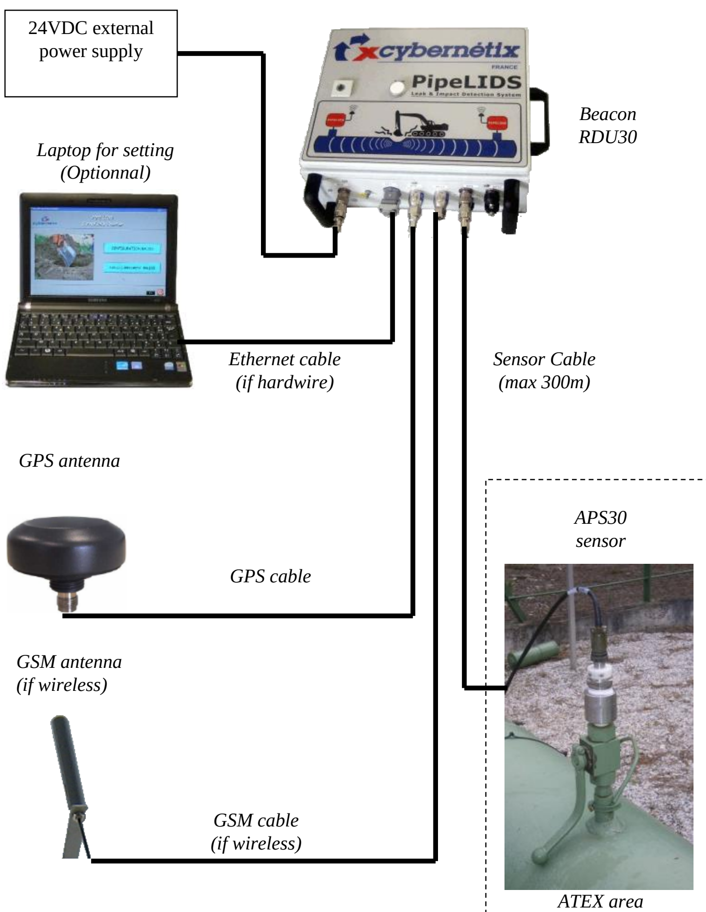


Fig. 2: Typical PipeLIDS components

Equipment improvement

A new generation of sensor, the APS40, has been developed to reinforce the PipeLIDS sensor robustness, and to ensure a high level of availability.

The new sensor consists of on a monoblock body, and new welded connector (**Fig. 3**). A crash test performed with an oil test bench has demonstrated the capability of the sensor to resist until more than 620 bars (9000 psi). The bottom part of the body was deformed but did not result in burst or rupture (**Fig. 4**). The sensor did not lose its seal.

Fig. 3: APS40 monoblock body and connector

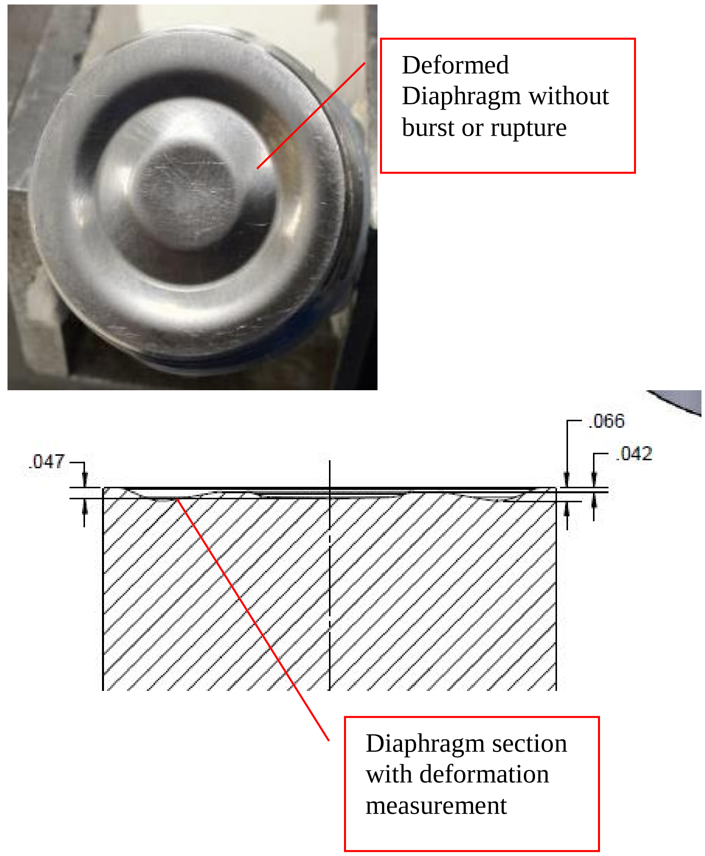


Fig. 4: APS40 diaphragm deformed during crash test

Following these results Cybernetix has qualified the APS30 sensor for low pressure application up to 30 bars, and the APS40 for pressure up to 150 bar.

The APS sensor could be mounted on a one inch NPT fitting or welded on a flange.

To protect the sensor's connector, a protection made of two shells is installed. This protection retains the cable and avoids strain on the connector itself. The protective shell is mounted directly on the sensor as shown on **Fig. 5** and **Fig. 6**.

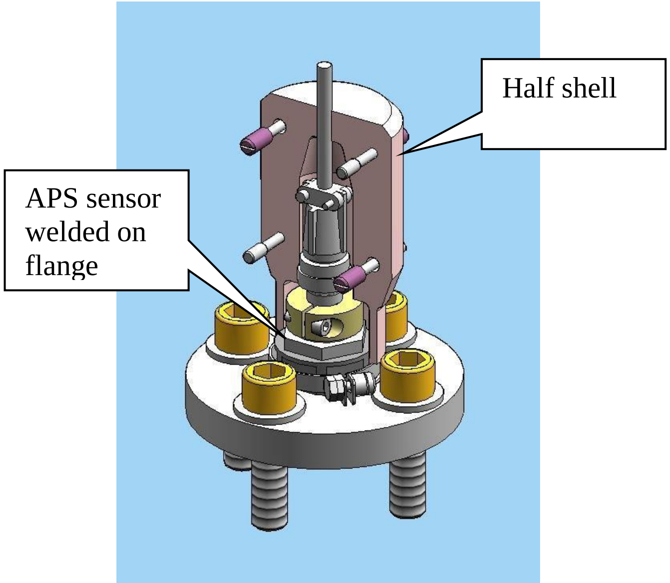


Fig. 5: Sensor half shell protection

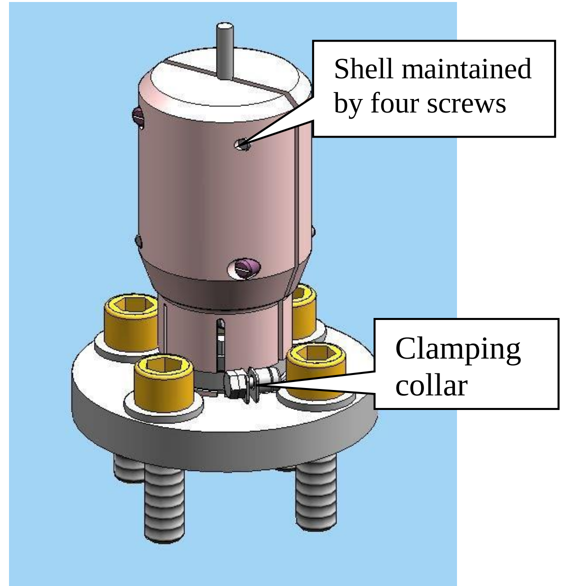


Fig. 6: Complete sensor shell in place

The PipeLIDS is a safety system and all material failures should be reported to the operator.

A new functionality enables automatic detection of problems with the sensor including short circuit, cable breakage, disconnection, or electronic failure (**Fig. 7**).

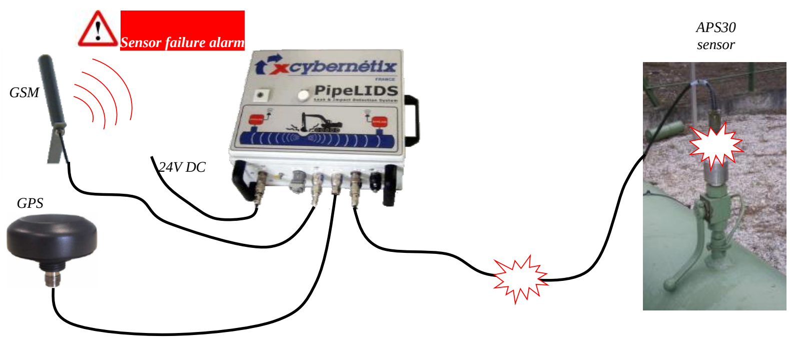


Fig. 7: Sensor failure alarm detection

The same type of improvement has been put in place concerning the GPS. In case of GPS loss, caused by cable or antenna disconnection, antenna failure, electronic failure, a corresponding message is sent to the operator (**Fig. 8**).

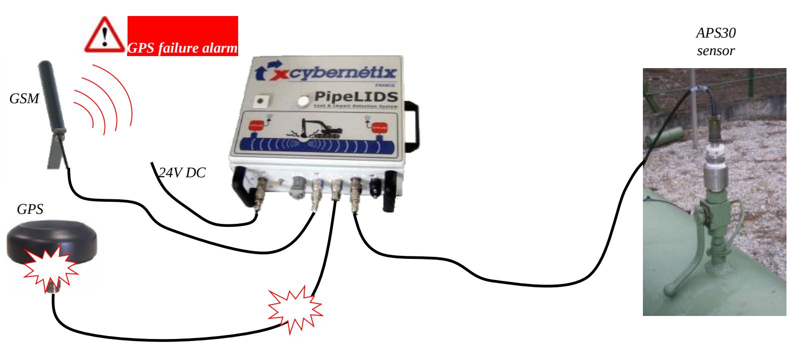


Fig. 8: GPS failure alarm detection

The power supply is also monitored and in case of power loss the internal battery powers up the PipeLIDS for 15 minutes or more, to give time to alert the operator (**Fig. 9**).

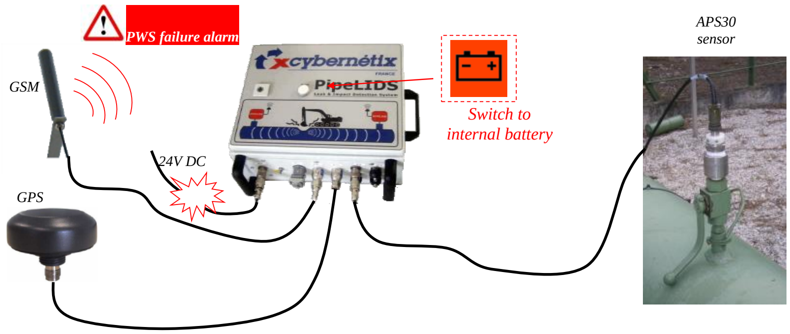


Fig. 9: Power supply failure alarm detection

In case of such a fault, an alarm message is automatically sent either to mobile phone or reported to the control room on the LISA display, to enable maintenance intervention as quickly as possible and to minimize downtime of the system.

Algorithm improvement

Reducing false alarms is a challenge faced by this kind of monitoring and inspection system, which led Cybernetix to continuously improve and develop new algorithms.

The PipeLIDS algorithm is programmed to monitor 10 frequency intervals. Depending on the Background Noise (BN), it is easy to change the limits of these intervals, and disable the nosiest bands if needed to avoid false detections.

Following different trials done in collaboration with various partners, a new algorithm was implemented, which increases the level of detection even in noisy conditions.

The multi-band frequency analysis is still used but this new algorithm analyses the whole spectrum and gives additional information which is complementary to the ten (10) standard frequency bands. If the ten (10) bands do not detect an event, this additional 11th band should be able to detect one, particularly in high BN conditions. The 11th band can be chosen to suit site conditions, but would typically be a summation of particular frequencies.

An example of the application of these algorithms for impact detections on a DN900 (35 inch) pipeline transporting natural gas at 50 bars is presented below. Impacts were simulated with a pendulum.

The sensor spacing was 10 km.

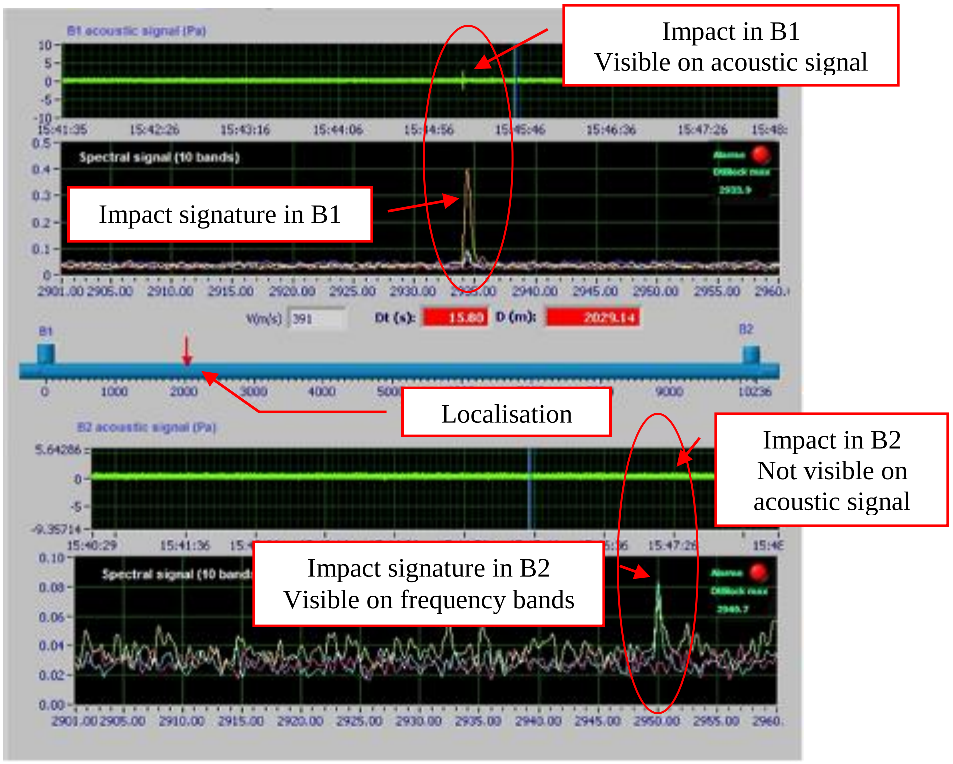


Fig. 10: Spectral analysis of 700 joules impact on 10 km gazoduc

In **Fig. 10** is presented an example of post processing of 700 Joules impact acoustic signals recorded by PipeLIDS on both measurement points B1 and B2. Fig. 10 presents the detection and localization post processing results.

The impact at 2 km from B1 is clearly visible on the acoustic signal and on the frequency bands.

At 8km from B2 the acoustic signal is only visible on some frequency bands. However the impact can be located at 2 km from B1.

Another test done in high BN condition is presented below on another part of the same pipeline. Impacts were simulated with the same pendulum system. The sensor spacing was 4 km.

The **Fig. 11** presents the spectral waterfall which show high back ground noise, caused by the compressor and flow in the line.

The 1000 Joules impact is not visible in the acoustic signal, as it is masked by the BN, but we can easily observe it on the spectral domain. The best frequency response is around 200 and 150 Hz.

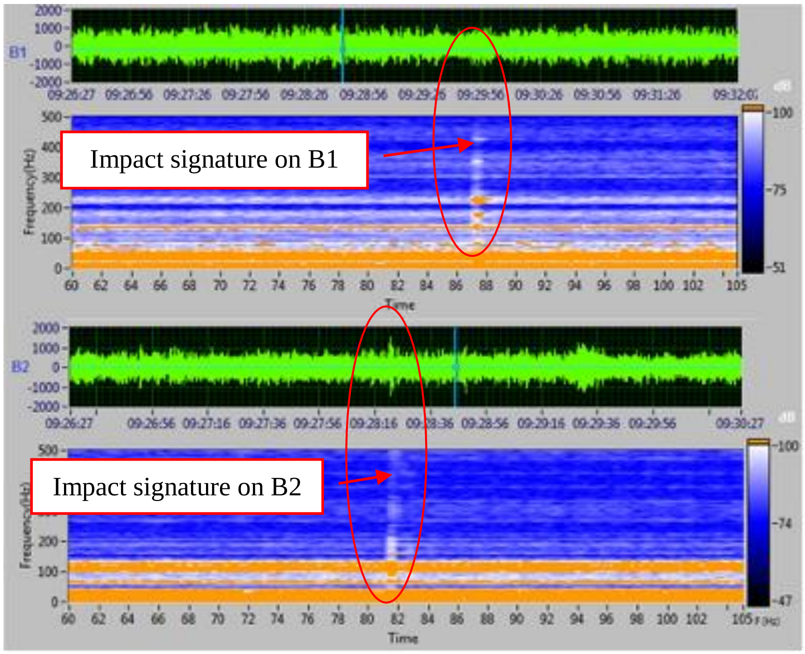


Fig. 11: Spectral analysis of 1000 joules impact on 4 km gazoduc

The **Fig. 12** presents the same 1000 Joules impact at 3 km from B1 which is clearly visible on particular frequency bands but not in the acoustic signal. The acoustic signal is visible on both acoustic and spectral signals of B2 at 1 km.

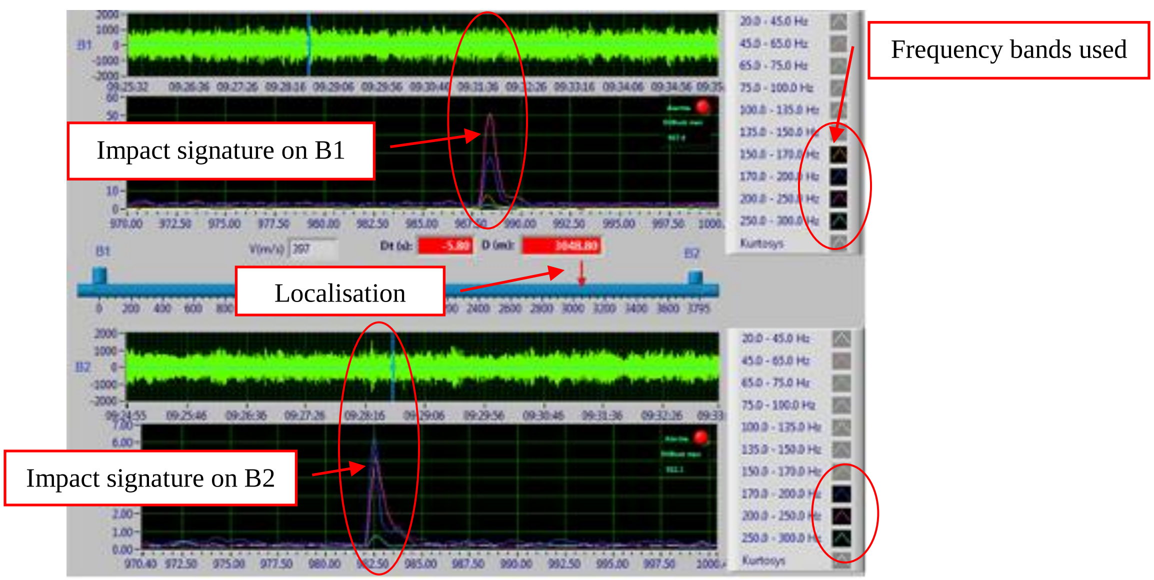


Fig. 12: Detection and localization of 1000 joules impact using frequency bands

By using particular frequency bands (set manually) the impact is located at 3 km from B1.
In **Fig. 13** the same 1000 Joules impact at 3 km from B1 is clearly visible on the 11th band and also at 1 km on B2. By using the 11th band (which is the sum of particular frequency bands) the impact is located at 3 km from B1.

Fig. 13: Detection and localization of 1000 joules impact using only the 11th band.

This demonstrates the power of the 11th band able to detect impacts even in high BN conditions.

During this test campaign, impacts over 123 Joules (equivalent to 12 kg failing from 1 meter height), have been detected and localized with an accuracy less than 1.9% (+/-72 m) of the sensor spacing. We observed that the BN was very noisy (+/-2000 Pa peak) particularly between 20 to 135 Hz. After analysis of this BN, the system settings were adapted to increase the signal/noise ratio and consequently the detection performances in such worth conditions. It should be noted that this analysis and tuning is the normal stage of a typical installation. Indeed the BN is a preponderant factor that can be only measured on site.

Some false alarms occurred on early installed systems. Too many detections were generated by the local RDUs, regardless of the filter used (sound speed, magnitude and spectral signature). This was caused by automatic thresholds that follow the noise seen by the sensors. The threshold is calculated as the noise average plus a multiple of the noise standard deviation. A very low noise (quiet environment) induces low average and very low standard deviation, resulting in a threshold very close to the noise measurement. This low threshold means that the system detects whatever happens in the pipeline, even if not dangerous for its integrity. At the opposite end, if there is a high level of noise, such as caused by civil or industrial activities in the vicinity of the pipeline or high flow or presence of compressor station close to the sensor, then the combination of high noise average and a high standard deviation results in too high a threshold and in a blind system.

The algorithm was updated to limit the detection by the use of a boundary threshold (minimum and maximum) that should be selected according to the BN encountered on fields. This setting could be done manually during the installation phase. The minimum threshold level limits the amount of detections caused by low magnitude sounds, and the maximum threshold level prevents a blind system, enabling detection even in high background noise.

Example of onshore application

These new features have been implemented and tested on the latest system installed on an SPSE 16 inch diesel pipeline in Fos sur mer (South of France).

SPSE was interested to monitor 1 km of pipeline used to transfer diesel at low pressure (<10 bar) between their storage area and another site.

A couple of APS30 sensor and RDU are installed at each extremity and connected by wireless GSM communication to the LISA display in the SPSE control room. The sensors are installed at the pig launcher at each side (**Fig. 14**), and the RDU is placed in a shelter outside the ATEX area (**Fig. 15**).

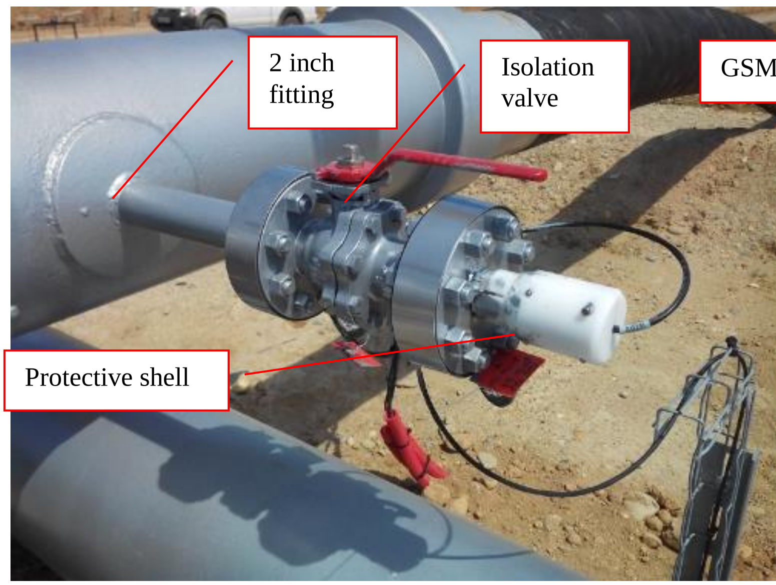


Fig. 14: Sensor and protection at SPSE side

Fig. 15: RDU beacon at SPSE external shelter

Pictures courtesy of SPSE

The commissioning was performed by simulating leak at the pig launcher at SPSE side. The leak was simulated by discharge of the product through a fitting equipped with a 12 mm ball valve towards a tank at atmospheric pressure (**Fig. 16** and **Fig. 17**). The pressure inside the pipeline was 2 bar.

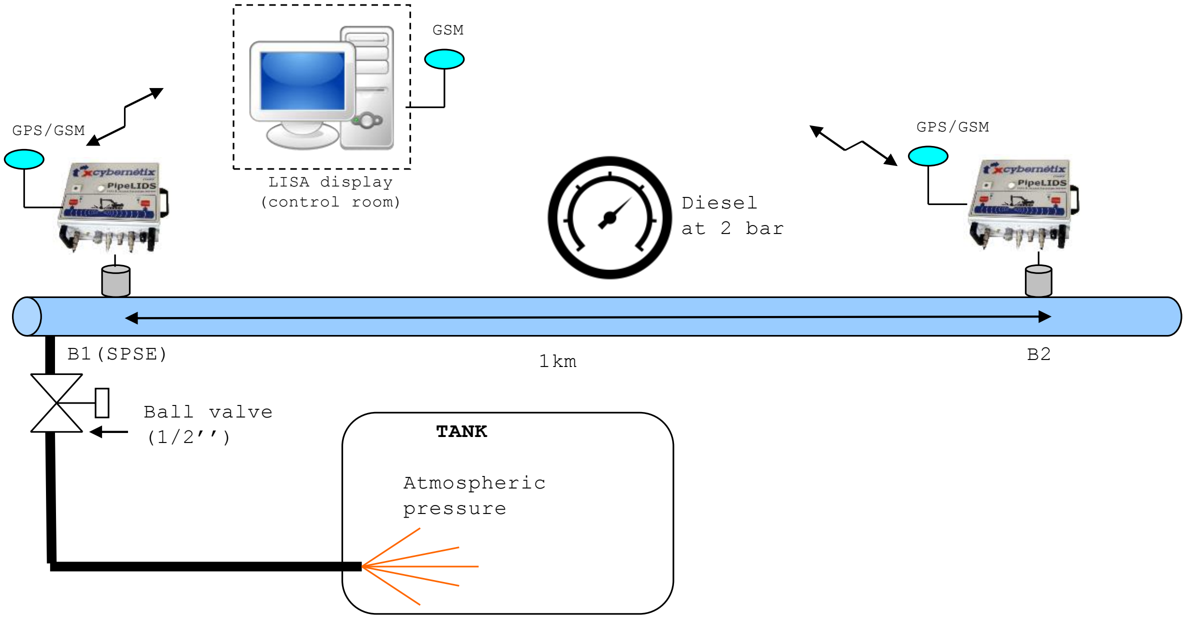


Fig. 16: Leak simulation overlay

Fig. 17: Leak simulation at SPSE pig launcher (courtesy of SPSE)

<u>Test pipeline stopped (no compressor running and valves opened):</u>

The acoustic signals recorded during the leak simulation are presented below.

The acoustic signal measured at the SPSE side (B1), where the leak was done, is plotted in green. The signal from the final side (B2) is plotted in red.

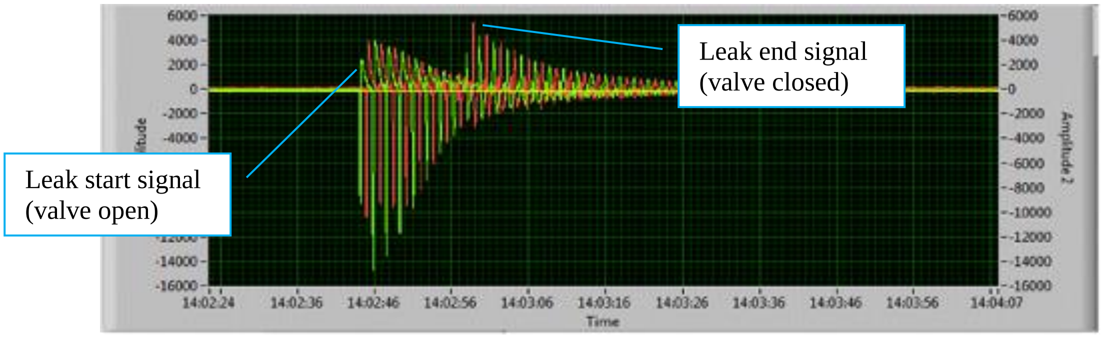


Fig. 18: Acoustic signal of leak simulation

In **Fig. 18** the acoustic signal of the valve opening is clearly visible and its shape corresponds to a wave characteristic of a depressurization. The subsidiary waves are caused by reverberation against the line extremity valves which were closed.

The acoustic signal of the valve closing appears with its characteristic shape corresponding to a pressure transient wave characteristic of a pressurization.

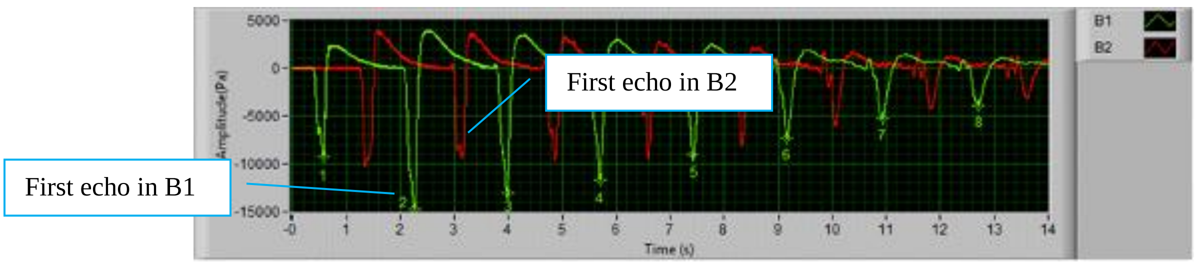


Fig. 19: Echoes caused by reverberation of the acoustic wave of the leak

In **Fig. 19** the green signal (B1) shows the depressurization of the line during the valve opening (label 1) followed by the red signal (B2) which shows the same signal measured on B2 (label 2). These are followed by the first echo in B1 (label 3), then the echo on B2 (label 4), and then subsequent echoes.

In **Fig. 20** presents the leak spectral response at each sensor point. We observed a low spectral signature on both B1 and B2 which is characteristic of a pressure surge caused by valve opening. The leak itself does not produce a sound all along its duration but the beginning and end of the leak are visible.

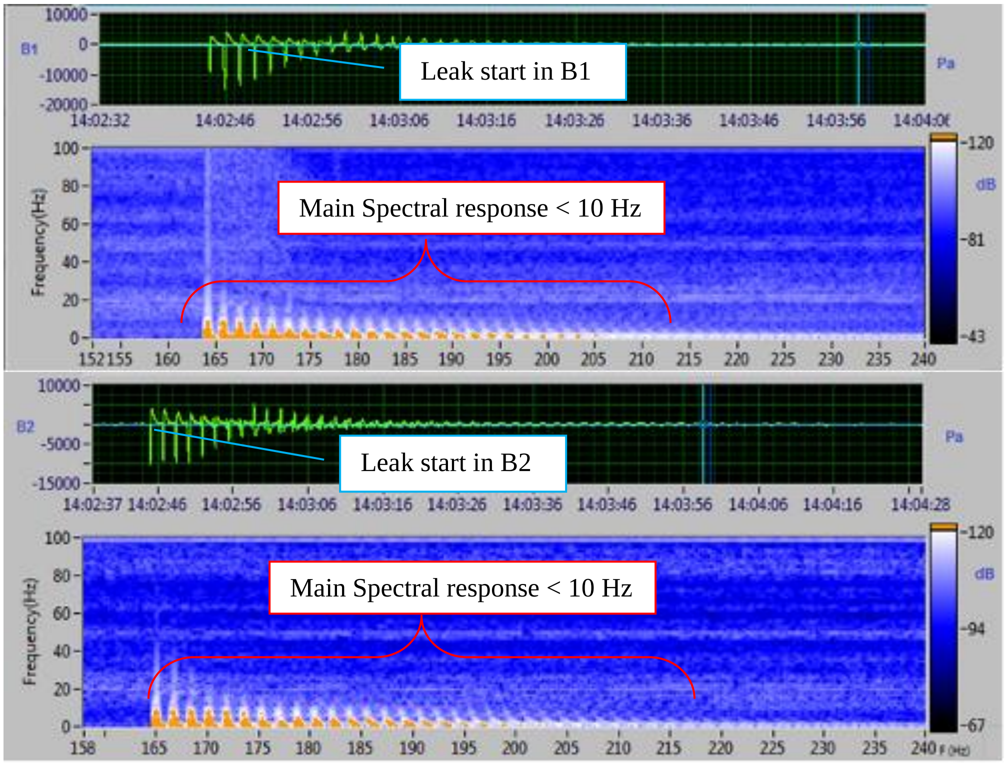


Fig. 20: spectral analysis of the leak simulation on B1 and B2

For each echo the wave travelled from B1 to B2 and then from B2 to B1 (round trip). One echo has travelled 2 km (double of distance between B1 and B2).

It should be noted that the first echo is less energetic than the second one. The first echo is a combination of the initial wave with its reflection against the closed valve located at 2 meters from the sensor. The second echo is more energetic as it comes directly from the other side of the pipeline. The pressure surge reflection principle is shown in **Fig. 21**.

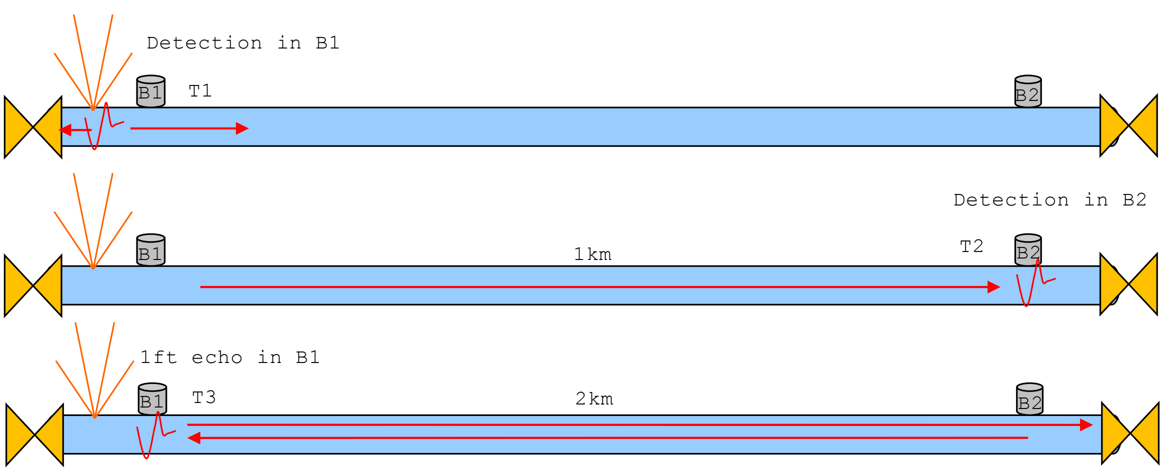


Fig. 21: Pressure surge echo travel

The echo amplitudes (see Fig. 19) can be extrapolated to find the maximum distance in a long pipeline at which this 12 mm leak could be detected.
A simple way to estimate the maximum detectable distance is to count the echoes that can be seen above the background noise: 8 echoes are seen meaning that this pressure surge can be detected at minimum of

8 echoes x 2 km = 16 km. It should be noted that the echo's amplitude decreases as energy is lots at each reflection

A second way is to calculate the acoustic attenuation of the pressure surge:

The average velocity and average acoustic attenuation processed using the formulas (see Equation 1 and Equation 2) are 1152 m/s and 1 dB/km respectively.

The energy produced by the leak is around 14600 Pascal (visible on the second echo on Fig. 19). Considering an average attenuation of 1 dB/km the maximum detectable distance, and if we consider that to be detected the wave should be higher than the background noise, the result is:

D = 20 LOG (N1/N2) / Attenuation

For low background noise (10 Pa): D = 20 LOG (20/14600)/1 → D = 57 km.

For high background noise (2000 Pa): D = 20 LOG (2100/14600)/1 → D = 16 km

It is very interesting to note that the pressure surge resulting of 12 mm diesel leak in a 16 inch pipeline could be detected at 57 km in such low pressure condition (2 bar). The same surge could be detected at 16 km with high noise in the pipeline (e.g. pump running).

The post treatment done by the system using the multiple frequency bands is presented below. The purpose is to demonstrate how the system detects and localize the leak simulation. The system automatically did this localization exercise during commissioning on site.

Fig. 22: Detection and localization of leak using frequency bands

In **Fig. 22**, the leak (pressure surge) and all the echoes are seen only on the low frequency bands, from 1 to 10 Hz.
The other bands are not sensitive to a pressure surge. However they may be used to detect impacts.
As show in Fig. 22, the algorithm does not locate the leak using only the frequency bands. This is caused by the several variations of amplitude of the echoes. Each echo produces a shock detection and not a leak detection.

Consequently the setting were changed to use the 11th band with the new algorithm. The result is presented here after in **Fig. 23**:

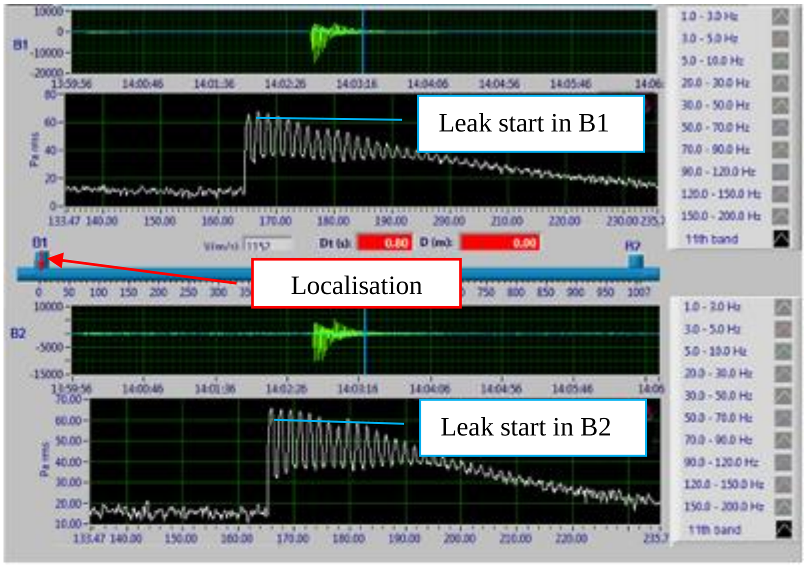


Fig. 23: Detection and localization of leak using the 11th band

In **Fig. 23,** the 11th band which is the sum of the low frequency bands enables detection of the leak as the global level is over its threshold. Using the 11th band, the leak is detected and located on B1 side.

Others bands, except the ones used on the 11th band could be used to detect impacts where the signature is between 30 to 80 Hz.

<u>Test with compressor running:</u>

Another leak simulation has been done with the line pump running to test if the leak is still detectable in noisy conditions. The pressure was around 4 bar during the leak.

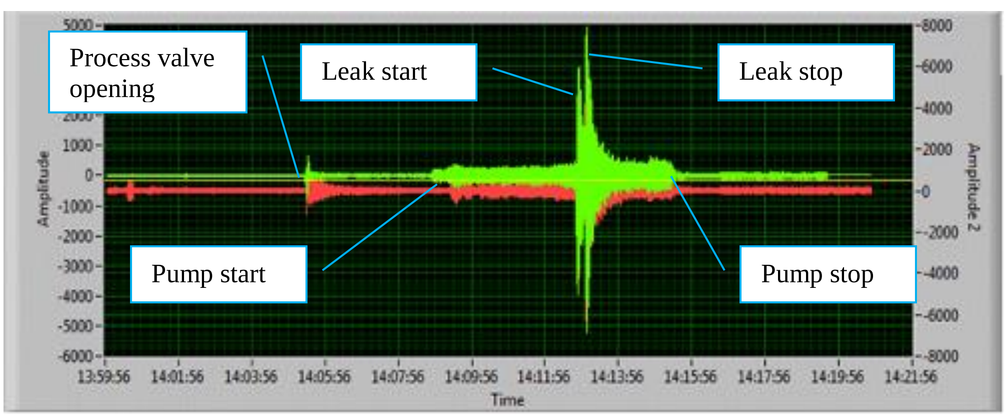


Fig. 24: Acoustic signal of leak simulation pipeline running

The acoustic signal of the process valve opening is clearly visible in **Fig. 24**, followed by the noise caused by the pump start, and the leak simulation. The leak simulation is easily visible even when the pump is running.

In **Fig. 25** the green signal (B1) shows the signal during the leak simulation valve opening followed by the red signal which shows the same signal measured on B2.

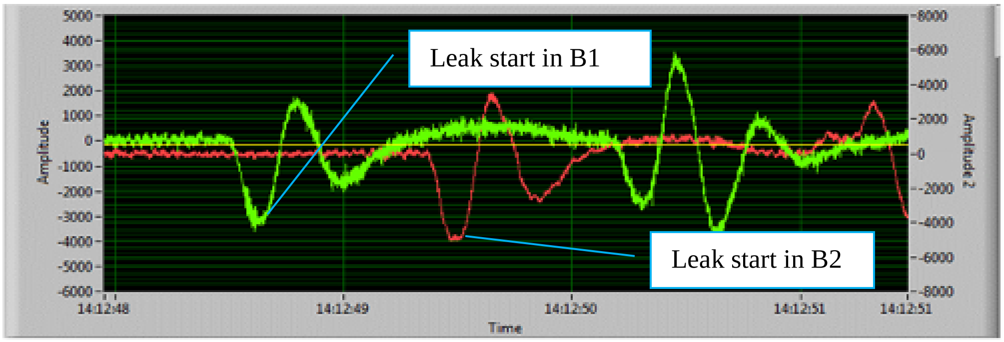


Fig. 25: acoustic signal of leak simulation start

In Fig. 25 the pressure surge of the simulated leak is visible as well as the echoes. It should be noted that the pressure surge energy is lower (3500 Pa) than the one observed during the previous test (10000 Pa) when the pump was stopped and the process valve closed. This shows that the pump running limits the depressurization and pressure surge in the line.

In this case also, the pressure surge and all the echoes are seen only on the low frequency bands from 1 to 10 Hz. The algorithm does not localize the leak using only the frequency bands. Again this is caused by the several variations of amplitude of the echoes.

The settings were changed to use the 11th band with the new algorithm. Using the 11th band the leak is easily detected and located on the B1 side.

In conclusion the leak simulation, even when the pump is running (producing a higher noise in the line), is detected and located using the correct settings.

Example of offshore application

The PipeLIDS system is not yet marinised for subsea use. Nevertheless it can still be used to survey part of a subsea pipeline on the condition that the sensors are installed at the surface, as shown on **Fig. 26**. The distance of pipeline which can be monitored is limited, but as demonstrated in previous chapter the detection and location of a pressure surge linked to a leak is possible.

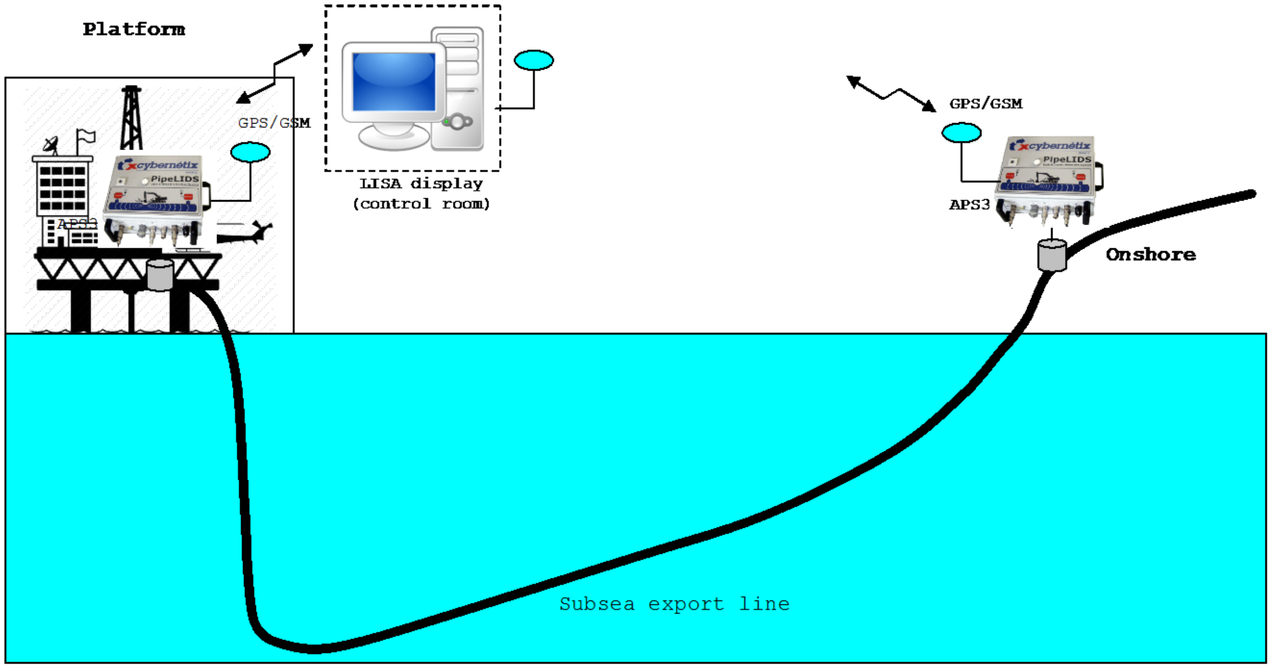


Fig. 26: Monitoring of subsea pipeline schematic

An example of application is presented here after. A test campaign has been performed in a 65 km 22 inch subsea export pipeline in Egypt. The purpose was to validate a leak detection using acoustic principle in such conditions. The pipeline was full of sea water at 22 bar during the tests.

Offshore sensor installation:

The ASP30 was installed on a 1 inch fitting directly at the arrival of the riser on the platform as shown in **Fig. 27** and **Fig. 28** during a testing campaign on a platform in Egypt.

Fig. 27: APS30 mounted on the arrival of the riser on the platform

Fig. 28: APS30 sensor with its drilling valve

Onshore sensor installation:

The ASP30 sensor was installed on a 1 inch fitting directly at the arrival of the riser on the beach as shown on **Fig. 29** and **Fig. 30**.

Fig. 29: view of the arrival on the beach

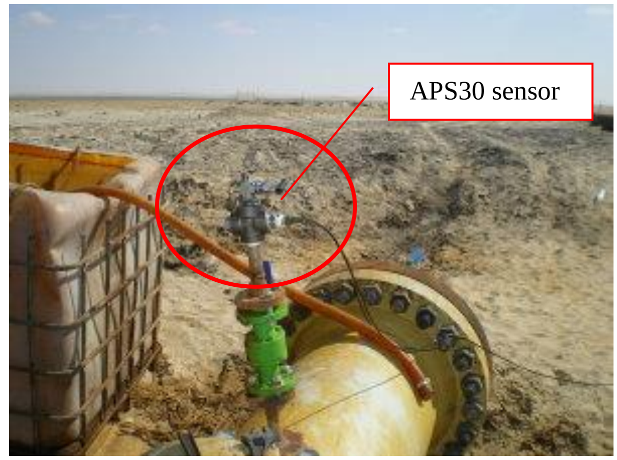


Fig. 30: APS30 mounted on the arrival

The opening of the drilling valve on the onshore side has been recorded, to be used as reference, and to estimate the acoustic velocity inside the pipeline. The Analysis by cross-correlation algorithm is shown on **Fig. 31**:

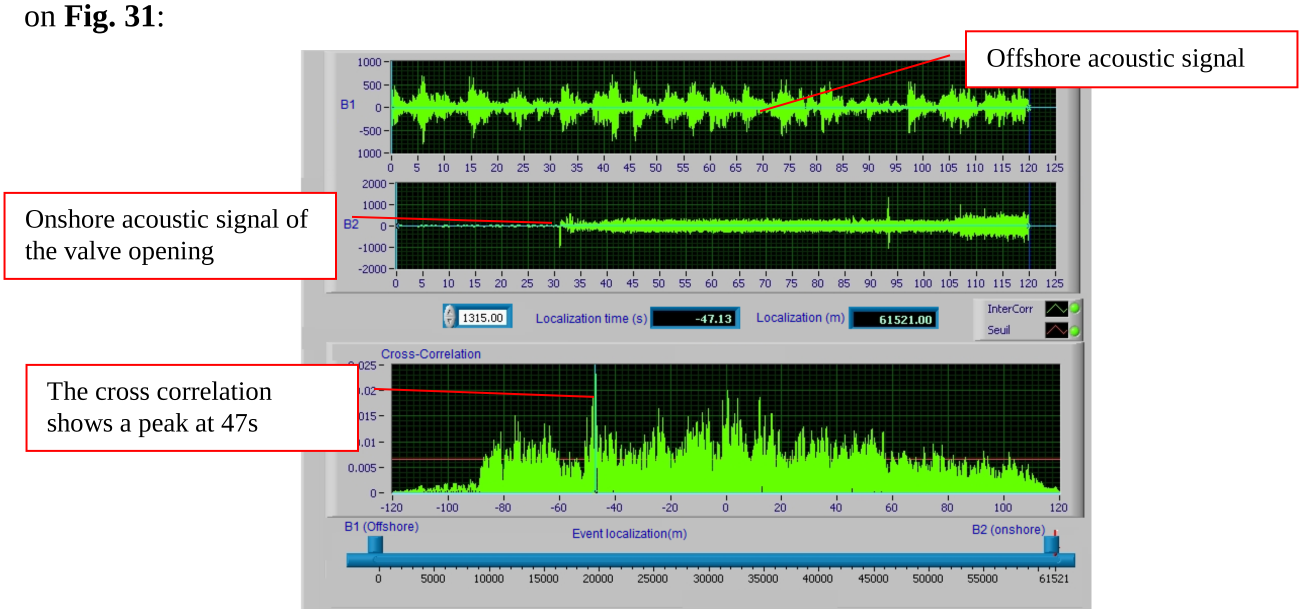


Fig. 31: Leak Start analysis by cross correlation

The pressure peak at 47seconds corresponds to the location of drilling on the onshore side. As the distance between sensors is 61.521 km the corresponding acoustic velocity inside the pipeline is 61521/47 = 1308 m/s.

First analysis by cross-correlation algorithm of the onshore valve opening (with a hole of ¾ inch) shows that only the pressure surge is detected by the platform sensor. Only the low frequency (0 to 5 Hz) of the simulated ¾ inch leak is transmitted along the 61 km of the pipeline, corresponding to the appearance of the leak.

During the leak the higher response frequency is between 5 to 50 Hz and is not transmitted to the platform.

Consequently these tests have shown that a leak occurring in the subsea pipeline between both sensors could be detected by using the frequency bands and the 11th band method as used in the previous chapters for onshore application.

Conclusions

During the last recent years, several actions have been conducted by Cybernetix to improve the leak and impact detection on pipelines using acoustic technology.

First studies were conducted to improve the material.

Cybernetix has developed a new robust generation of hydrophone sensor, the APS40, with a high level of availability and qualification for pressures up to 150 bar.

The previous sensor generation, the APS30, is still qualified for low pressure application up to 30 bar.

A shell protection has been designed to maintain the cable and to avoid strain on the connector. Automatic monitoring has been added so that any equipment failure, such as sensor or GPS or power supply, is reported to the operator immediately.

Later studies focused then on the algorithm improvements. The new algorithm increases the detection in noisy conditions with high background noise in the pipeline. To reduce false alarms, minimum and maximum boundary thresholds have been introduced.

These new improvements have been used on the latest system installed for SPSE on a diesel pipeline and will soon be used on a new crude oil section.

A leak was simulated during commissioning by a ½ inch (12 mm) valve opening. It was demonstrated that the pressure surge linked to the valve opening and closing is visible and could be detect at 57 km in low noise conditions, and at 16 km in case of high noise in the pipeline.

Finally the PipeLIDS system is not yet marinised (although studies are in progress), but can be used for subsea pipelines for topsides to topsides applications.

Acknowledgments

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Nomenclature

APS30	Acoustic Pressure Sensor 30
ATEX	ATmospheres EXplosibles
BN	Acoustic Background Noise
EMC	Electromagnetic compatibility
IP	Ingress Protection
GPS	Global positioning system
GSM	Global System for Mobile Communication
LISA	Leak Impact Software Application
NPT	Pipe tapered Thread
Pa	Pressure unit in Pascal (1 Pa = 10^{e-5} Bar)
PipeLIDS	Pipe Leak and Impact Detection System
RDU	Remote Data Unit
RMS	Root mean square
SCADA	Supervisory Control and Data Acquisition
SMS	Short Message
SPSE	Societe Pipeline Sud Europeen
TCP/IP	Transmission Control Protocol/Internet Protocol