



No more wires

Hatem Nasr, vMonitor, USA, talks about how wireless sensor networks can monitor critical pipeline operations, providing continuous flow information.

In recent years, there have been significant advances in Wireless Sensors Network (WSN) technology, making it possible for oil and gas companies to deploy it on pipeline systems to improve safety and efficiency. WSNs are being implemented to continuously measure pressure and flow, and to monitor leak detection across vast pipeline networks. vMonitor has been involved in several WSN pipeline projects. This article provides an overview of two recent applications. The first application involved the deployment of a large network of wireless sensors to monitor pressure across a large pipeline section in Mexico. The WSN also provides remote control capabilities that allow operators in the main control centre to take action in the event of an incident. The second application involved the implementation of a novel wireless sensor system to monitor wells and pipeline leak detection offshore Nigeria. This system provides timely data on wells and the underwater pipeline, enabling operators to detect problems as soon they occur and potentially prevent failures.

While WSN technology has made significant advances, there are still many limitations preventing large scale commercial rollout for pipeline systems. Some of these limitations that vMonitor had to address are best exemplified by some of the critical requirements in the two above-mentioned projects. These requirements include:

- Ability of the wireless sensors to communicate over long ranges (up to 5 km) and still use battery power.
- Perform control functions (such as valve actuator control), if needed, and implicitly have two-way communication
- The ability to collect data at a high frequency (every 1 - 30 ses), but only transmit data every 1 - 2 mins in order to preserve battery life.
- Mexico pipeline – WSN for pressure monitoring and control

Pemex Gas and Petroquimica Basica (PGPB) is the division of the Mexican National Oil and Gas Company - Pemex - responsible for transporting the gas and basic petrochemicals across the country. PGPB has efficiently managed its vast network of pipelines with a control centre located in Mexico city and has a large portion of the pipeline integrated into its main SCADA

Figure 1. Pemex PGPB pipeline network.

Figure 2. Example of accidents caused by pipeline theft and sabotage in Mexico.

system. However, it has never had any continuous information about the operational conditions of the pipelines that transport basic petrochemicals including propane, ethane, methane, heavy crude and light crude between the processing centres which comprise a total

power and communication links. All power sources such as solar panels or battery banks, even copper cables and instruments, were stolen or damaged. Given this major constraint, low-power, battery-operated wireless sensor was the only practical approach. In addition, many parts of the pipeline network goes through private properties, so digging and trenching cables for communication and power proved to be extremely complicated.

To address these problems, a new generation of wireless sensors (Figure 3) by vMonitor was installed. These wireless sensors are packaged in a low profile explosion proof enclosure with the full assembly painted the same colour of the pipeline, making the equipment look like part of the piping. The equipment is completely autonomous, operating from an internal battery pack that could transmit every 5 secs. This self sufficient wireless design also eliminated the need for any type of wiring.

PEMEX evaluated both wired and wireless solutions for this project, concluding that a wireless solution provided a better business case based on the evaluation criteria that wireless solutions provide a total saving in installation costs that exceeded 70% of wired solutions.

vMonitor's wireless pressure sensors (vMBusX-SP) were installed on the pipeline at nearly 190 stations (Figure 4). The wireless sensors transmit data once every 5 - 30 secs. This transmission frequency was adopted after evaluating the SCADA system polling cycle providing a one year battery life. The data is transmitted to a nearby Gateway, which is in turn connected to the main SCADA system (in the capital Mexico City) through an existing long-range UHF backbone communication network.

The Gateways are polled once per minute through UHF base station from the SCADA system. In addition to receiving remote data, the network can also be used to direct commands to a particular remote station. This will be most useful in the future for control applications of solenoid valves to control the sectioning valves for security in case of leaks or anomalies that has caused many HSE incidents in the past.

The wireless sensor system architecture main components are:

- ➔ Multiple numbers of wireless sensors at each pipeline monitoring station creating a mesh network reporting to one wireless Gateway Data Concentrator.
- ➔ A Point-to-Multipoint Gateway in the centre of this mesh, receiving messages from all wireless sensors registered with the corresponding Gateway.
- ➔ The Gateway maps data from wireless sensor messages into their relevant registers according to their identification tag.
- ➔ The Gateway is serially connected to the UHF radio network.

Figure 3. vMonitor vMBus wireless pressure sensor.



Figure 4. vMonitor Wireless Sensors Installed on Pemex PGPB Pipeline

of approximately 600 km of pipelines (Figure 1).

PGPB wanted to deploy new wireless sensor technology to monitor and properly manage the vast ageing pipeline network and provide rapid access to remote data such as gas pressures from all sectioning and transport valves across the network. Operators in the control room as well as processing centres and process final destinations are to be able to provide operational alarms and monitor status and operating conditions of the pipeline, as well as monitor with high degree of confidence real time pressure trends. Another important goal of the system is to detect any anomalies caused by acts of sabotage and theft (Figure 2) which have proven to be highly dangerous.

Wireless sensors offer several advantages over conventional technology

The choice of WSN by PGPB was largely driven by several historical challenges when PGPB attempted to install conventional SCADA systems, which require



DRAFT

The SCADA Polling engine gets data from the Gateway utilising the UHF/Microwave communications backbone network.

Nigeria offshore – wells monitoring and pipeline leak detection

Many oil companies with offshore operations are facing the problem of leak detection in pipelines connecting the offshore wellhead platforms to the land production facilities. Any such leak presents a major HSE (Health, Safety and Environmental) implication. In the event of any incident, the clean-up process is very expensive, poses major environmental hazards, and can expose companies to serious litigations.

Many of these companies, operating Nigeria offshore assets, are also faced with another challenge of being able to detect problems that can cause well shutdown. Currently, if a well is shut down, oil companies detect lower production, but cannot isolate which well is shutdown, or how to locate that particular well. Operations personnel must visit all the production wells to find the well that is shut down and then match the final deficit amount to the day's production. If there are several wells that have shut down, it becomes extremely difficult to isolate those wells. The cost involved in visiting all the wells is staggering, and the production loss due to the wells shut down is estimated at 4 - 5% annually. Many of the problems can be prevented with the right wireless sensors technology.

Today, most if not all the offshore production platforms do not have any remote monitoring or control capabilities. Conventional SCADA systems and traditional wireless communication could not be implemented in most locations in Nigeria because these traditional systems require solar power and solar system are constantly stolen or vandalised. The only option is to install wireless sensors technology that is small, discrete, tamper-proof and battery powered.

Pipeline leak detection system

Any leak detection software system requires either flow information, or continuous pressure data from the two points of the pipeline being monitored. So the challenge in this application is how to obtain flow or continuous pressure data for the leak detection software using low power wireless pressure sensors that are designed to transmit intermittent data (every few minutes).

In order to monitor the pipeline for leak detection, vMonitor installed a series of wireless pressure sensors at the two ends of the pipeline (Figure 5), which were battery-powered. The leak detection software required, at a minimum, pressure data every 2 secs.

In order to preserve the battery life on the wireless vMBusX-SP sensor (Figure 6), vMonitor modified the firmware on the wireless sensors so it could collect data every 2 secs, buffer the data, but only transmit data every 1 min. This was crucial for the leak detection



Figure 5. Offshore pipeline leak detection system using Wireless Sensors.



Figure 6. Battery operated vMBusX-SP wireless pressure sensors transmitting pressure data for pipeline leak detection system.

software which required a minimum of 2 secs pressure data. Transmitting data every 2 secs over a range of several kilometers would have drained the battery in a few weeks because the highest power consumption occurred when the radio was transmitting. This allowed the wireless sensor to be almost continuously 'on' to collect data every 2 secs, but only be over the air every two mins.

The pressure data from the wireless sensors was transmitted to a Gateway/Data Concentrator (vMBusX-G), which in turn sent the data to vMonitor's data acquisition TotalAccess software, and TotalAccess filtered and transmitted the data via an OPC connection to the Leak Detection System (LDS) Software. vMonitor had set up two separate software servers, one for TotalAccess (Figure 7) for data SCADA functions, and one LDS. The LDS software (Figure 8) then performed the pressure wave calculations in order to detect any potential leaks on the pipeline. The reliability and the repeatability of leak calculation depended on the reliability and accuracy of the data collected by the

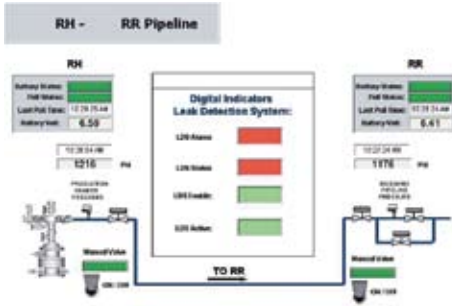


Figure 7. TotalAccess Software System showing leak detection status and alarms.

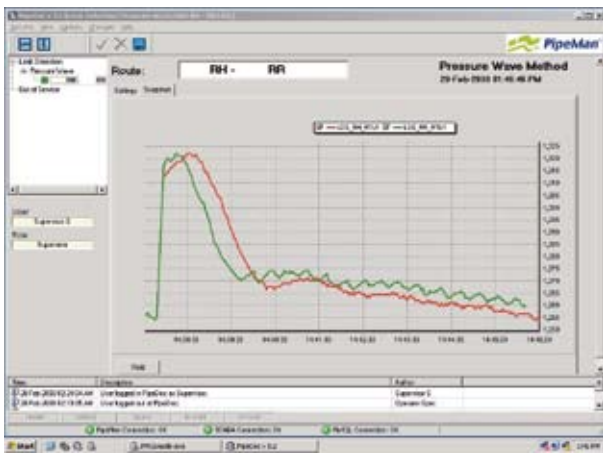


Figure 8. Pressure wave from leak detection software identifying pressure pattern in the pipeline.



Figure 9. Please supply caption.

vMonitor wireless sensors. The data transfer efficiency of the Wireless System had to be 93 - 96% in order for the LDS Software to claim a high leak detection accuracy. It is important to note that this LDS was designed to detect major leaks in the pipeline. The LDS

Software uses Pressure Wave Analysis method, which detects pressure wave that is generated due to a leak in the pipeline and based on the time of capturing this wave at each end of the pipeline, the leak location is identified and the wave amplitude determines the possible leak size.

Wireless sensors delivering clear benefits

The wireless sensor network system installed on the Mexico has dramatically improved operational efficiency of the pipeline. The clear benefits include:

- ➔ Improve the safety, prevent and reduce theft and sabotage incidents.
- ➔ The wireless solution has provided a total saving in installation costs that exceeded 70% of wired solutions
- ➔ Project execution time was another clear edge, whereby in two months a sensor network on nearly 190 sites was installed. Installing a conventional system would have taken almost one year.

The Nigeria system is proving several immediate benefits to the operator as well:

- ➔ The system has increased chances of detecting leaks within matter of minutes as opposed to days.
- ➔ Remote well monitoring is preventing well shutdown and potentially increasing production by 3 - 5%, by quickly isolating problems and shut down wells, and preventing future failures.
- ➔ Eliminating unnecessary trips to the pipeline and wells, and reducing potentially logistics OPEX by more than 50%.