# Integrated Data Acquisition and Control Trends in Oil and Gas Pipelines

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Discovering and extracting oil is becoming increasingly challenging, and technology is rapidly evolving so engineers can better address the challenges of drilling, transporting and producing oil. Currently, two important trends are occurring: PC-based data acquisition and PLC-based control systems are merging, resulting in hardware systems commonly referred to as programmable automation controllers (PACs), and new graphical system design software languages are allowing control engineers to target real-time operating systems and embedded hardware. Graphical system design languages and PACs combine high-speed measurements with real time deterministic control while simplifying the programming of these new advanced systems. The benefit for control engineers is they can now make better measurements and perform tighter control.

Engineers and control system experts are using these new technologies in a wide range of applications from drilling control systems, to pipeline monitoring systems like ones deployed at Shell and the Ormen Lange pipeline in North Sea, to tank farm monitoring for 43 percent of oil produced in Mexico with PEMEX.

### PACs Used in Managed Pressure Drilling

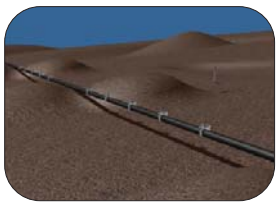
Managed pressure drilling is a technique that tracks the complete pressure profile of a well during the drilling process while dynamically adapting to well conditions to meet desired drilling parameters. Impact Solutions Group developed a patented managed pressure drilling technology called Secure Drilling based on LabVIEW and National Instruments PACs.

The Secure Drilling method is a managed pressure drilling system based on the patented Micro-Flux Control method that monitors the dynamic flow rates in and out of the well. With high-speed monitoring and adaptive control technologies, the Secure Drilling system can automatically control the back pressure at the surface to maintain well control.

System designers implemented the adaptive and flexible control algorithms at the center of the Secure Drilling system. A state machine architecture was developed using the LabVIEW Real-Time Module to monitor six process variables and perform real-time data trending. The system functions in two modes, user controlled, with automatic alarm generation, or active control. In active control mode, the program uses one of three control algorithms:

- LabVIEW PID control algorithms with gain scheduling
- LabVIEW implementation of the Cybosoft Model Free Adaptive (MFA) control software
- LabVIEW fuzzy logic control algorithms

### Monitoring Ormen Lange Pipeline in the North Sea



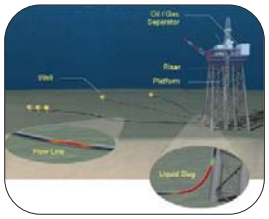
The Ormen Lange is the largest natural gas field under development on the Norwegian continental shelf. The pipeline traverses the Storegga rock slide off the coast of Norway, which is one of the longest rock slides to exist on a continental shelf. A massive mound of rubble has accumulated over thousands of years, causing an extremely rough seabed for laying natural gas pipelines. The installation of a real-time vibration monitoring system on the subsea pipeline is required to predict and quickly react to any damage.

The Norwegian firm of Bjørge AS, which specializes in intelligent underwater instrumentation and condition monitoring, has developed a long-term monitoring system entirely in LabVIEW for installation at the Ormen Lange. Assisting in hardware development is Schmid Engineering, a Swiss system integrator that offers solutions for mechatronics applications and embedded systems.

The monitoring system must survive extreme sub-sea conditions including strong underwater currents, low visibility, limited power, Gulf Stream currents, water turbulence due to the uneven seabed and changes in internal pipeline flow. In addition to these extreme conditions, the project required a tight development timeline to meet production targets, a very low power off-the-shelf hardware deployment platform, and a highly reliable system with built-in logging capabilities.

### Slug Flow Monitoring and Control at Shell

Pipelines or flowline/riser systems transport liquid hydrocarbons, gas and water from satellite wells to a central production platform. Shell often selects a single pipeline for economic reasons. Ideally, a pipeline would produce a constant amount of gas and liquid. In a single pipeline, however, segregated flow of liquid and gas may cause problems.




To prevent this segregated or slug flow, Shell Global Solutions developed the Slug Suppression System, S3 and licensed it to Dril-Quip for marketing, sales and manufacture. The S3 consists of a miniseparator positioned between the riser top and the normal first-stage separator. The miniseparator has two outlets, one for the gas flow and one for the liquid flow. Valves control both outlet flows, which receive their signals from a control system. This control system uses LabVIEW Real-Time software and NI Compact FieldPoint distributed I/O. The control strategy suppresses severe slugging and controls transient slugs without gas surges.

The S3 control system relies on two redundant FieldPoint PACs. The PACs provide information for gathering and control. With this redundancy built in, the availability of the

system is 99.95 percent, assuming a four hour repair period for any downtime.

The control system is programmed with LabVIEW using standard PID control toolset blocks, plus additional algorithms to ensure correct and fast control of the slug suppression system when modes of control are changing. Implementation in existing PLC and DCS tools is not straightforward because of the complexity of these additional control algorithms, but LabVIEW provided the correct set of tools and abstractions.

### PEMEX Monitors Oil Production

PEMEX Exploration and Production (PEP) oversees the exploration, production, transportation and commercialization of oil extracted in Mexico. PEP's Southern Region Transportation and Distribution Management is responsible for transporting and distributing Olmeca, Istmo and Maya crude oil. PEP transports and distributes approximately 1.52 million barrels of this oil daily, which represents 43 percent of national production. This volume is equivalent to 3 billion dollars in crude oil.

To determine precisely the oil volume PEP transports and distributes, PEP relied on electronic measurement systems installed in the field. Previously, coordination between the different management teams and separate measurement systems was done by phone and e-mail. PEP needed an integrated monitoring system that would enhance coordination between these teams and take advantage of existing measurement systems for the transportation and distribution of crude oil.

The crude oil monitoring and management system, known as Sistema de Monitoreo de Variables Operativas (SIMVO), had to meet the following requirements:

- **Easy Communication** - The system had to link the different communication networks through industrial protocols and standards. For this application, PEP chose OLE for Process Control (OPC) to communicate with different stations.
- **Low Cost** - To reduce the total cost of the project, the internal engineering team needed to be able to develop the application.
- **Reuse of Existing Infrastructure** - Because measurement and control systems and an Intranet were already installed, SIMVO had to be able to use the existing field equipment.
- **Network Security** - PEP needed an additional industrial network to protect the system from virus attacks, unauthorized personnel access and version incompatibility.

After evaluating software options on the market, NI LabVIEW and the LabVIEW Datalogging and Supervisory Control (DSC) Module were chosen. The development environment includes several features that met the project needs. LabVIEW is compatible with the OPC specification, which means it works both as a client and as a server, making it possible to communicate with the different measurement instruments in the field and between the different monitoring stations. Additionally, the graphical programming environment made it easy for the PEP engineering group to develop the entire application in-house, from communication between measurement systems to the user interface to the report generation.

### Graphical System Design and PACs Deliver Flexibility

A wide range of applications across multiple industries can benefit from graphical system design approach and the hardware capabilities of PACs. In the oil and gas industry a wide range of drilling, monitoring and production companies are using These type of software programs to address the challenges they face and develop new innovative solutions.

***References:*** *Deploying a Managed Pressure Drilling System based on NI LabVIEW and Compact FieldPoint http://sine.ni.com/cs/app/doc/p/id/cs-11281*

*Shell Stabilizes Long Pipeline-Riser Gas/Liquid Flow http://sine.ni.com/cs/app/doc/p/id/cs-230*

*Deploying LabVIEW to Monitor Pipelines at the Ormen Lange in the North Sea http://sine.ni.com/cs/app/doc/p/id/cs-10512*

*PEMEX Uses NI LabVIEW to Implement a Crude Oil Distribution System http://sine.ni.com/cs/app/doc/p/id/cs-786*

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