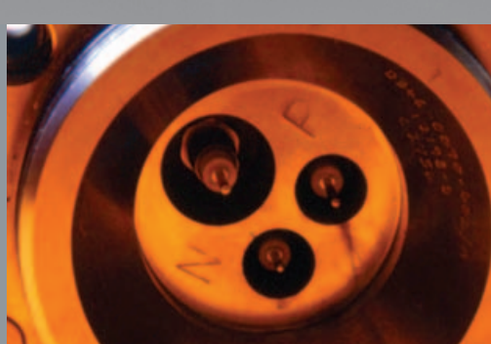
Schlumberger

Phoenix Artificial Lift Downhole Monitoring



Improving artificial lift system performance

Applications

- Lift system and completion performance monitoring
- Wells with potential startup or instability problems
- Wells with changing productivity and sandface conditions over time
- Reservoir drainage and depletion monitoring

Benefits

- Reduced deferred production through longer lift system run life
- Lower operating costs through better lift system management
- Reduced early well-life failures

Features

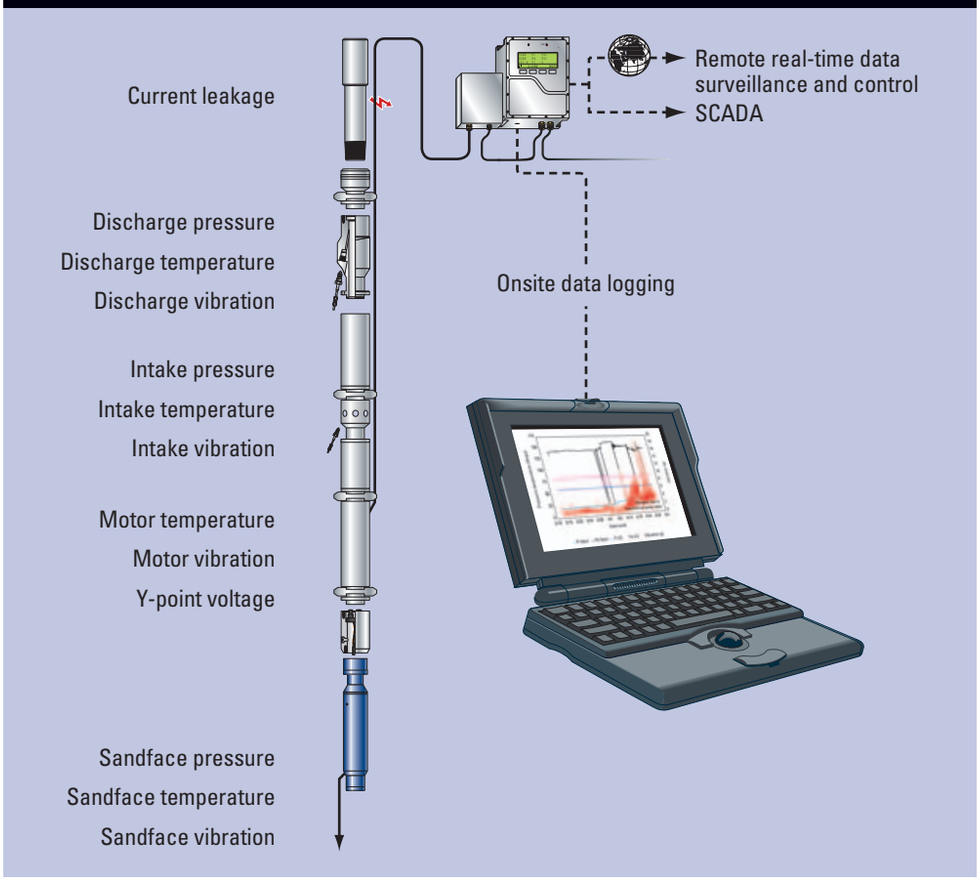
- Optimization of pump and production performance
- Optimized well intervention planning
- Family of instrumentation adaptable to any lift system or application
- Accurate, continuous monitoring of multiple key parameters
- Compatible with supervisory control and data acquisition (SCADA) systems using Modbus protocol
- System operation independent of pump power
- Continuous data stream via RS232 and RS485 ports on surface equipment
- Programmable trip and alarm relays for all parameters monitored
- Analog outputs and inputs
- Onsite historical data storage using data logger
- Selectable rapid sampling rate for reservoir monitoring

Optimized performance

Phoenix* artificial lift downhole monitoring systems enable optimized production and lift system performance in wells with an electrical submersible pump (ESP), a progressing cavity pump (PCP), a beam (rod) pump, or a gas lift completion. Real-time monitoring tools and accurate data reduce the need for operator intervention, improve well integrity, and maximize production and ultimate recovery. Phoenix systems can protect assets and help ensure both the reservoir and completion deliver to their full potential.

Proactively identifying problems results in substantial cost reduction when there are prompt and effective remedial actions. Good data eliminate the guesswork that can result in ineffective and costly intervention strategies. With accurate downhole information, operators can make better decisions to optimize well production.

Available measurements from the Phoenix Select monitoring system configured for an ESP completion.*



Monitoring System Parameters

Parameters Measured	MultiSensor* XT Type 0	MultiSensor XT Type 1	Select CTS	Select LITE	Select Standard	Select Advanced†	Select Reservoir
Current leakage	•	•	•	•	•	•	•
Discharge pressure		•	•		•	•	•
Discharge temperature			•		•	•	•
Discharge vibration			•		•	•	•
Intake pressure	•	•	•	•	•	•	•
Intake temperature	•	•	•	•	•	•	•
Intake vibration						•	
Motor temperature	•	•		•	•	•	•
Motor vibration	•	•		•	•	•	•
Motor Y volts				•	•	•	•
Sandface pressure							•
Sandface temperature							•
Sandface vibration							•
Temperature rating (°F [°C])	257 [125]	257 [125]	302 [150]	302 [150]	302 [150]	302 [150]	302 [150]
Pressure accuracy (psi [kPa])	±10 [69]	±10 [69]	±5 [34]	±5 [34]	±5 [34]	±5 [34]	±3 [21]

† Phoenix Select Advanced gauge measures pump intake pressure at the pump, allowing detection of blocked intakes.

Systems to suit your artificial lift needs

Whatever your artificial lift method, Schlumberger provides a Phoenix downhole monitoring system for your application: the Select digital gauge—configurable for all lift systems—and the MultiSensor XT analogue ESP monitoring tool.

Monitoring System Applications

Monitoring System	ESP	PCP/Beam pump/ Gas lift/Jet pump
MultiSensor XT	•	
Select	•	•

Improving ESP and well performance

ESP artificial lift systems are effective field-proven completion systems particularly suitable for wells with low bottomhole pressure, low bubblepoint, high water cut, and high volumes. ESP systems often replace gas lift when there is insufficient gas to sustain the flow. Either the Phoenix Select or MultiSensor XT monitoring systems can monitor ESP and well performance. Careful monitoring will extend pump run life and contribute to improved production. Together this helps reduce your total lift system costs.

Achieving optimum performance from PCP systems

PCP systems produce high efficiencies, are a low-capital investment, and reduce maintenance and operating expenses. When effective data are used, PCP wells achieve significant improvements. An extensive database and experience enable Schlumberger to recommend the right Phoenix gauge for the job.

Optimizing production in gas lift wells

Catastrophic failures in many artificial lift systems are abrupt. Production immediately declines—or drops to zero—and the causes are often obvious. A failing gas lift system, however, may not be noticed for weeks or even months. While some of the effects of the failure appear as lower production rates, these rates could also be easily attributed to conditions other than a failing or inefficient gas lift system. Consequently, a loss of production can rapidly add up to tens of thousands of barrels.

Monitoring and protection for beam pump systems

Pressure data taken below the beam pump helps monitor drawdown and can prevent the unit from pumping off. Vibration monitoring gives warning of pump wear or pounding. In addition, buildup surveys using real-time pressure measurement below the pump are conducted without pulling rods and running slickline memory gauges.

Phoenix Warning Measurements in ESP Applications

Measurements	Application
Current leakage	Alarm protects electrical system from deterioration from high pump heat, breakdown of winding insulation, and phase-to-ground insulation loss.
Discharge pressure	High-pressure alarm and trip protect the pump from closed-valve shut-ins and heavy fluid slugs.
Discharge temperature	High-temperature alarm and trip protect the pump from overheating.
Intake pressure	Low-pressure alarm and trip protect the pump from low-fluid level, pump-off due to blocked intakes, and gas locking.
Intake temperature	High-temperature alarm and trip protect pump from high-temperature intake recirculation and elevated production fluid temperature.
Motor oil or winding temperature	High-temperature alarm and trip protect motor from low-flow conditions, high motor load, and poor cooling because of scale.
Motor and pump vibration	Vibration alarm protects pump from mechanical damage from high-solids production and excessive mechanical wear resonance frequency.
Y-point voltage	Motor Y-point voltage alarm detects imbalance in the electrical system downhole.
Sandface pressure	Pressure measured remotely from the ESP facilitates accurate transient analysis of build surveys for well performance monitoring.
Sandface temperature	Well temperature is measured away from the ESP, unaffected by its heating.
Sandface vibration	Vibration measures remotely from the ESP providing early indication of solids production.
Pressure differential	Low- or high-pressure alarm and trip protect the pump from upthrust in high-flow conditions and downthrust in low-flow conditions.

Phoenix Warning Measurements in PCP Applications

Measurements	Application
Discharge pressure	High-pressure trip protects the pump from closed-valve pressure buildups and accidental shut-ins.
Pressure differential	High-pressure alarm and trip protect the pump from running out of head range.
Intake pressure	Low-pressure alarm and trip protect the pump from low-fluid level, pump off, and damage from high gas volumes.
Temperature protection	High-temperature trip protects pump from high-temperature conditions.
Pump vibration	Vibration alarm protects pump from mechanical damage from high-solids production and excessive stator wear and resonance frequency.

Phoenix Warning Measurements in Beam Pump Applications

Measurements	Application
Intake pressure	Low-pressure alarm and trip protect the pump from low-fluid level, pump-off, and damage from high gas volumes.
Pump vibration	Vibration alarm protects pump from mechanical damage from high-solids production and excessive mechanical wear and pounding.

Phoenix Warning Measurements in Gas Lift Applications

Measurements	Application
Annulus pressure	Sensor system automatically detects and warns of injection pressure change and pressure instability downhole.
Tubing pressure	System warns of increasing weight in the tubing column from poor injection or increasing water cut.

Measurement flexibility

The Phoenix Select and MultiSensor XT monitoring systems offer a broad range of downhole measurements for multiple artificial lift system types and manufacturers. With flexibility in the configuration of your downhole monitoring system, you can be confident in selecting the right system for your application.

A technician verifies Phoenix gauge quality during manufacturing.

Reliability built in

Schlumberger has a history of high-quality, reliable downhole measurements and has been producing downhole gauges for over 60 years.

The accelerated life testing approach is now standard for Schlumberger downhole tools. This process is adapted from the aerospace and automobile industries and applied to the unique demands of the oil field. Emphasis is placed on testing early in the development cycle by the application of stress cycles in excess of the operational limit. Schlumberger products are submitted to temperature cycles, shock cycles, and vibration testing.

Pressure testing the Phoenix MultiSensor XT downhole gauge.

Select system for PCP.

Select system for gas lift.

Select system for beam pumps.

Field applications

Phoenix monitoring systems protect your artificial lift system. Each measured parameter can be programmed with a shutdown threshold and linked directly to the lift drive system, protecting your assets against damaging conditions. The units, in combination with a SCADA or remote surveillance system, warn instantly when a well's operating performance changes. The operator, or a control system, can then take quick and effective remedial action to restore optimum oil production or system performance. In addition, a normally operating artificial lift system can be continuously optimized to react to changes in operating conditions.

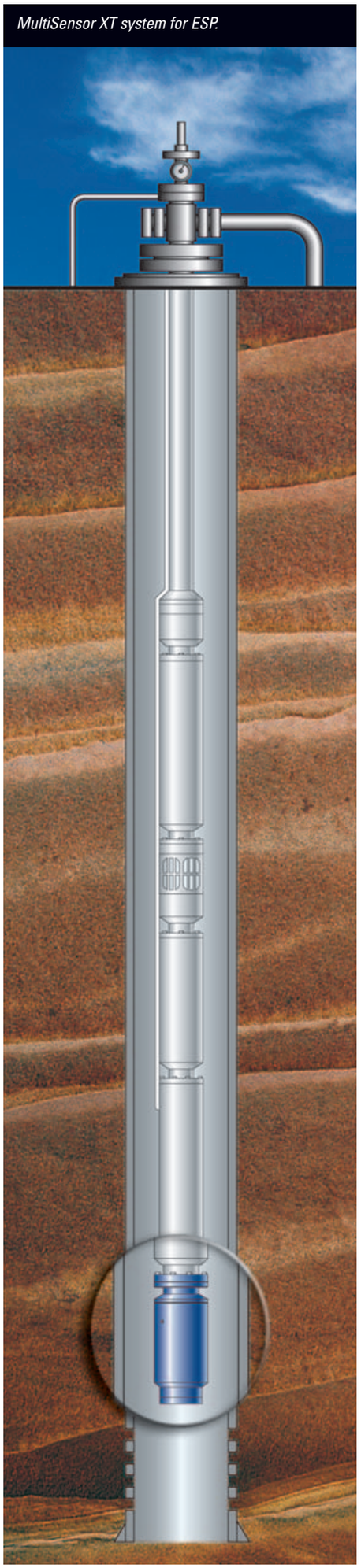
The Phoenix system also provides valuable information about productivity and reservoir performance, including opportunities for pressure transient analysis, inflow performance monitoring, and productivity trending. The Phoenix data is a powerful complement to the operator's reservoir performance-monitoring program.

Compatibility and integration

With a high level of control and protection, Phoenix systems are SCADA-ready. The Modbus remote terminal protocol port provides remote monitoring and control. Both the RS232 and RS485 port options are onboard for a continuous data stream as required. In fields with multiple artificial lift systems, Phoenix technology means one data acquisition and communications platform for all wells.

The UniConn* universal site controller provides operators with a single common platform for protection, control, and data acquisition (both local and remote) for all ESP applications—fixed speed or variable speed.

Phoenix systems are also designed for compatibility with real-time remote systems. Schlumberger offers the espWatcher* surveillance and control system for ESPs.



MultiSensor XT system for ESP.

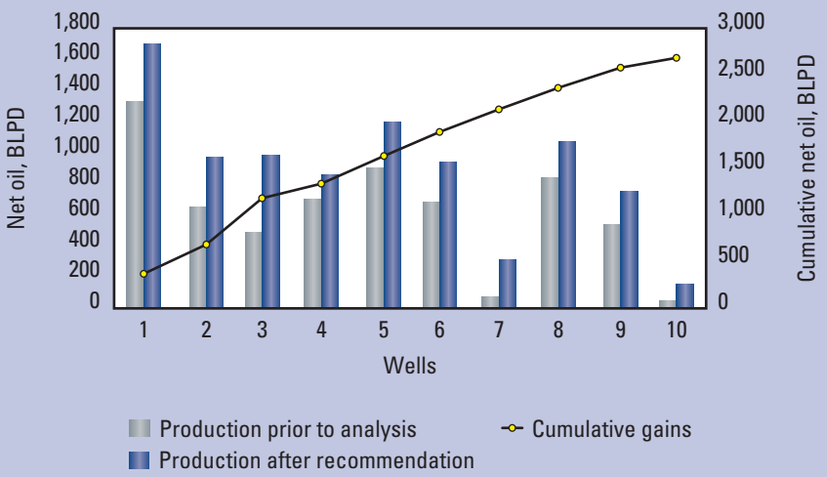
Reliability and experience

Phoenix sensors have been helping operators manage their artificial lift operations since 1992. The MultiSensor system was the world's first multiparameter ESP gauge and has now been installed in more than 2,000 wells worldwide. Additionally, Schlumberger has been the industry leader in downhole permanent monitoring systems since they were first introduced in the early 1980s. Significant experience and success have continually improved the quality and reliability of our downhole sensors. The same commitment and dedication have enabled Schlumberger to deliver the latest generation of sensors in the Phoenix Select system.

The value of data

Downhole measurement data from Phoenix Select and MultiSensor systems are used for in-depth analysis, diagnostics, and remediation planning in wells and fields on artificial lift. The production increases for one operator, shown below, are the result of analysis and recommendations from the LiftPro* optimization service utilizing Phoenix gauge data.

Results of effective use of data. Significant production gains using Phoenix monitoring and LiftPro optimization.



ESP performance monitoring using the espWatcher service.

A systems approach extending to the reservoir

Schlumberger has developed a modular systems approach to improving artificial lift well performance. Our approach deploys high-quality, reliable lift products, such as REDA* ESP and Camco* gas lift systems, instrumented with Phoenix monitoring equipment. Next, the espWatcher surveillance and control system and the LiftPro optimization service make full use of instrumented downhole lift systems to optimize system and well performance.

This systems approach can be extended to include field optimization studies that evaluate and provide the following:

- well performance modeling
  - data validation
  - fluid and reservoir inflow conditions and performance characterization
  - completion design, diagnostics, and matching the completion to existing wells
  - individual well performance curve development
- field system modeling
  - flowlines, pipelines, and manifolds modeling
  - well performance curves
- integration of episodic measurements and interventions
  - production tests and pressure transient tests
  - PVT* pressure-volume-temperature software and sampling data incorporation
  - integration of other surface measurements or ad hoc production logging
  - integration of well stimulation or treatment services.

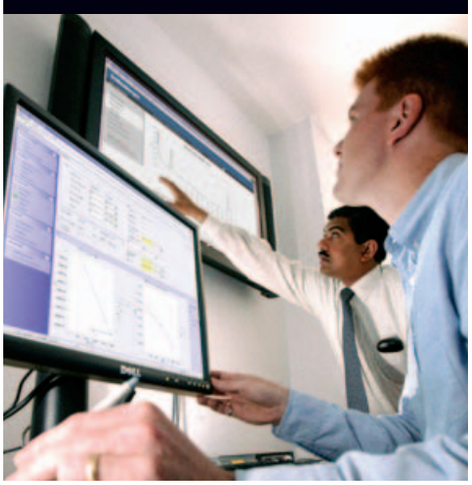
espWatcher service

The Schlumberger espWatcher surveillance and control service for ESP systems features remote data acquisition; data transmission, alarms, and alerts via satellite; remote pump startup and speed control; and remote resolution of certain pump problems. The espWatcher service is enabled by InterACT* real-time monitoring and data delivery. Remote connectivity and viewing of REDA ESP systems, variable speed drive (VSD) controllers, and Phoenix artificial lift monitoring systems contribute to improved production and lift system performance.

The espWatcher service can help improve the operation of submersible pumps and well production in a number of ways:

- surveying pump performance against pump curve models
- surveying well performance against well models
- comparing VSD operating plans to updated models of the pump and completion
- detecting early changes in reservoir and sandface properties
- maintaining formation integrity and controlling water coning
- making pressure transient tests.

Production optimization through espWatcher and LiftPro services.



Supported by Schlumberger Data & Consulting Services, the service is an end-to-end data acquisition and management service to ensure minimized risk and a high level of performance.

The flexibility of the espWatcher service makes it suitable for mature fields with a large number of producing wells, remote environments where physical access is restricted or difficult, or in fields where SCADA is limited or unavailable.

Analysis and interpretation

The key to any meaningful performance analysis is synchronized and validated data. Phoenix systems form an integral part of the LiftPro service to identify and remediate underperforming artificial lift wells. This rigorous four-step optimization process relies heavily on the right data to deliver more oil and a longer well life.

LiftPro service

Approximately two out of three artificially lifted wells have the potential for significantly improved operation and increased production. The LiftPro service baseline performance goal is to tune a well's operation for a 10% increase in net oil production. The LiftPro service

- identifies an underperforming artificially lifted well
- uses the appropriate technology to identify why the well is underperforming
- provides recommendations and implementation
- validates results.

The Schlumberger LiftPro service consists of these four steps:

Acquire

- Candidate selection is an important part of the optimization process. Only wells with a high potential for gain are targeted.

Analyze

- Artificial lift and well testing expertise is combined with advanced well diagnosis tools, such as LiftPro XP artificial lift system analysis software.

Execute

- The sensitivity of well performance for various parameters can be precisely predicted.

Evaluate

- A complete dataset, available on demand at the wellsite or delivered remotely, enables operating personnel to test settings efficiently and accurately. The result is prompt before-and-after well production results with a very short turnaround to improved well operation.

The LiftPro service uses a proven array of permanent and temporary data acquisition systems, such as Phoenix monitoring systems, Sensa* fiber optics, and PhaseTester* multiphase periodic well testing equipment.

POCKET

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