Permanent monitoring systems

WellWatcher* permanent monitoring systems integrate the most advanced permanent downhole measurement technology with surface acquisition and data communication systems to enable remote monitoring of wells and reservoirs in real time. Pressure, temperature, vibration, strain, fluid density, and flow rate data are transmitted to surface and can also be transmitted to remote locations via satellite, the Internet, or cable.

Permanent downhole gauges
Permanent downhole electrical gauges and associated systems obtain highly accurate, stable, and reliable point measurements of pressure, temperature, flow rate, and fluid density.

Distributed and electric gauges and sensors
Fiber-optic distributed temperature, vibration, and strain sensors and arrayed electric pressure and temperature gauges acquire data over extended wellbore intervals in real time to identify the time, location, and reasons for changes in flow.

Reliability — The Key to Downhole Measurements
All components of the WellWatcher system are rigorously tested and qualified to meet the highest standards for reliability.
Permanent Downhole Gauges
Highly accurate, stable, and reliable point measurements

Measurements of pressure, temperature, flow rate, and fluid density

WellWatcher Quartz LT® high-resolution PT gauge
- Rated to 10,000 psi [68,947 kPa] and 206 degF [110 degC]
- Maximum 6 gauges per cable

WellWatcher Quartz® premium high-pressure, high-resolution PT gauge
- Rated to multiple pressures of 10,000 psi [68,947 kPa], 16,000 psi [110,320 kPa], 25,000 psi [172,368 kPa], and 30,000 psi [206,843 kPa]; and up to 356 degF [180 degC]
- Maximum 8 gauges per cable

WellWatcher Quartz Extend® AC- or DC-powered high-resolution dual-sensor PT gauge
- Rated to 16,000 psi [110,316 kPa] and 302 degF [150 degC]
- Maximum 10 dual gauges per cable

WellWatcher eQuartz® ESP-immune high-temperature, high-resolution PT gauge
- Rated to 25,000 psi [172,369 kPa] and 392 degF [200 degC]
- Maximum 8 dual sensor gauges per cable

FloWatcher® flow rate, fluid density, and PT monitoring system
- Rated to 25,000 psi [172,368 kPa] and 347 degF [175 degC]
- Compatible with all WellWatcher permanent monitoring systems
Remote site and icy conditions present monitoring challenges
A well in a remote, environmentally sensitive area of Alaska required real-time downhole monitoring. The site was cold, difficult to reach, and had no permanent power source. The monitoring system has to be installed in the 4 months before the roads made of ice began to melt. Also in these 4 months, a road and well pad had to be constructed, the rig moved onsite, and the well drilled and completed.

Compact, lithium battery–powered monitoring system streamlines installation
The WellWatcher Remote battery-powered PT monitoring system was selected. Its small replaceable lithium battery eliminated the need for a permanent electric power supply or solar panels, which are frequently stolen but were not an option because of the short daylight time in Alaskan winters. Its miniaturized remote acquisition unit was easy to transport. The long-life lithium battery met the high reliability standards needed in the remote location. After well abandonment, the equipment could be easily and inexpensively moved to another site.

Use of monitoring system saves 4 days and USD ½ million
The WellWatcher Remote system operated as planned and was left in place for several months to monitor downhole pressure and temperature and ensure well integrity until the well was permanently abandoned. Months later, an engineer sent to the site to recover the equipment found the system still working. By eliminating the construction and other time-consuming requirements of traditional power sources, the operator saved an estimated 4 days and USD ½ million.

Individual well production allocation is difficult in wells with shared pipeline
An operator and its partner were developing remote offshore North Sea fields that had several subsea wells tied in to adjacent fields. These fields were developed together with several gathering points but shared a common pipeline. The two companies had different allocation workflows but lacked adequate information about the performance of the individual wells. Because well interventions to test individual wells are expensive, and individual well production allocation could not be achieved without disrupting the total production from all the wells, they needed a way to obtain consistent data and to develop separate but consistent reservoir models.

Improved allocation tracking enhances recovery strategies
The results—independently validated by multiphase flowmeter calculations—showed that one of the three wells was producing at a much higher rate than initially allocated and that no water had been produced for the first 2.5 years. Because the wells were tied in together at the gathering point and the performance of one well affected the performance of the others, the data automatically implied that the remaining two wells had produced less than initially thought. The operator was able to understand the production allocation of the three wells without the time, expense, and added risks of testing the wells individually.
More Than 14,000 WellWatcher Permanent Monitoring System Gauges Deployed in Over 50 Countries Worldwide

Schlumberger deploys enough permanent downhole cable to circle entire globe.

Schlumberger is the industry-recognized permanent monitoring leader, having deployed more than 14,000 permanent downhole pressure and temperature gauges in over 50 countries over the past 42 years.

Distributed measurements over extended wellbore intervals

Distributed temperature and pressure measurements
- Distributed temperature sensing (DTS) fiber-optic technology for permanent monitoring can provide temperature measurements over long intervals extending up to the complete length of the wellbore.
- Alternatively, an array of point sensors can be used to obtain distributed measurements. Multiplexing several pressure gauges provides distributed pressure measurements.
- The highly sensitive data can identify the source of changes in well performance as they occur rather than later during a production logging run, enabling accurate diagnostics for gas lift systems, monitoring of completion integrity, and quick identification—without interrupting production—of a faulty valve or unstable flow.
- Interpretation and real-time communication software applications provide critical data for reservoir analysis workflows. Acquiring data from multiple wells provides an overall reservoir perspective that can help operators optimize the number and placement of wells to maximize production and recovery and contain costs.

WellWatcher Neon® DTS, DAS, and PT gauge system
- Distributed temperature and vibration, pressure
- Rated to 15,000 psi [103,421 kPa] and 347 degF [175 degC]

WellWatcher Flex® digital temperature array and PT gauge system
- Distributed temperature, pressure
- Rated to 20,000 psi [137,895 kPa] and 362 degF [183 degC]

WellWatcher BriteBlue* digital DTS fiber
- Distributed temperature, vibration, and strain
- Rated to 347 degF [175 degC]

WellWatcher BriteBlue HT* high-temperature, high-resolution DTS fiber
- Distributed temperature, vibration, and strain
- Rated to 572 degF [300 degC]

Technologies
- Early permanent quartz pressure and temperature gauges
- WellWatcher Sapphire PT gauge
- WellWatcher Quartz premium high-temperature, high-resolution PT gauges
- WellWatcher Quartz LT high-resolution PT gauge
- WellWatcher Quartz Extend AC- or DC-powered high-resolution dual-sensor PT gauge
- FloWatcher flow rate, fluid density, and PT monitoring system
- WellWatcher Remote battery-powered PT monitoring system
- WellWatcher eQuartz ESP-immune high-temperature, high-resolution PT gauge

Location
- Over 50 countries

First installation
- 1972

Total installations
- >14,000

Background
- Schlumberger has been developing downhole permanent gauge technologies since 1960—ensuring the best possible quality control and industry-leading reliability. Advancements in connector design, tougher electronic housing, and iterative product development have resulted in continuous improvements in the survivability of Schlumberger gauges—a rate now higher than 95%.

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Distributed Measurement Systems

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THERMA* thermal modeling and analysis DTS software was used to analyze the distributed temperature data and calculate flowing well temperatures on the basis of reservoir, fluid, well, and completion properties. Variables that control flow in the reservoir, such as permeability, were adjusted until the measured and calculated data coincided.

Analysis of commingled production optimizes management of multilayered reservoir

The DTS data and analysis of the complex zonal commingled production allowed earlier detection and prevention of internal crossflow zones during well clean-up. Zonal pressure and rate profiling optimized the zonal completion design with the downhole zonal sliding side door, which enabled better management of the reservoir layer drawdowns and layer inflow split.

Optoelectric DTS and PT gauges monitor individual zones simultaneously

A dual-string multizone completion with a WellWatcher Neon DTS, DAS, and PT gauge system allowed the pressure and temperature of each zone to be monitored individually. The WellWatcher Neon system added a fiber-optic DTS line to the permanent downhole cable, enabling simultaneous acquisition of pressure gauge data and distributed temperature data. WellWatcher Quartz premium high-temperature, high-resolution PT gauges operate as usual on an electrical conductor, while the fiber-optic line operates independently of the electric conductor and does not affect its reliability. The system was installed at each reservoir perforation and interval, making it possible to calculate flow contributions, crossflow, and other critical factors for each zonal layer’s flow and depletion characteristics.

Case Studies

Stacked reservoir complicates zonal allocation

An operator was redeveloping an oilfield offshore east Malaysia. A well was drilled to explore the deeper layers of the reservoir, for which very little information was available. The sandstone multizone reservoirs were stacked, with some distinct shale barrier separation. Reservoir predictions had indicated significant variations in the reservoir layers. In such reservoirs with uncertain behavior and commingled production, determining zonal allocation is critical yet challenging. Reservoirs have traditionally been monitored by wireline logging, reservoir saturation logging, and surface well testing, but these techniques often result in deferred production, increased intervention risk, and higher surveillance costs. The operator asked Schlumberger to design a completion and monitoring system to evaluate the zonal flow and depletion behavior of this reservoir.

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WellWatcher Neon DTS, DAS, and PT Gauge System

Determines Behavior of Multilayered Reservoir Offshore Malaysia

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Reduced temperatures from August to October revealed the layer where depletion had occurred. From this information, a new flow distribution model was created, and changes to the reservoir management strategy were put in place.

Test data form the basis of a thermal well model. Matching this model and the actual measured DTS profile produced an initial flow profile that could be recalibrated over time to enhance water injection and reservoir management.

Improved reservoir management strategy optimizes drainage of secondary oil

The continuous temperature profiles of individual reservoir zones enabled the effects of differential depletion to be monitored over time. BP improved its reservoir management strategy for water injection and oil drainage—optimizing the drainage of more than 100 million barrels of secondary oil.

BP Optimizes Drainage of More Than 100 Million Barrels of Secondary Oil from Reservoir Offshore Azerbaijan

Operator needs drainage strategy to ensure capture of secondary production

BP was developing a portion of an oil field offshore Azerbaijan. The main producing formations consisted of layers of sandstone interbedded with shale. More than 100 million barrels of secondary production were at risk of being bypassed because of the reservoir’s characteristics. The development and management strategies required a good understanding of the conformance between the producer and injector wells both by geography and by formation. The use of conventional logging would have shut down production while the tool was being run in hole, increasing rig time and costs. The operator needed a faster, more efficient way to manage reservoir performance.

DTS fiber identifies reservoir properties and calculates flow rate

The WellWatcher BriteBlue multimode DTS fiber was installed to provide distributed temperature profiles that could be monitored at the surface in real time. Unlike production logging tools, the fiber requires no intervention after installation. The fiber was installed on the outside of the sand screens over the reservoir interval so that it would react to the temperature changes of each flowing layer. Fluid flows from a reservoir into a wellbore because of a pressure drop. This fluid movement and subsequent Joule-Thomson effect cause the fluid to change temperature from its normal geothermal value. When the reservoir fluid passes through the sand screen to the wellbore, it mixes with the flow coming up the basepipe from layers below, and the temperature again changes. These two temperatures—Joule-Thomson and axial mixture—along with reservoir properties and well test data form the basis of a thermal well model. Matching this model and the actual measured DTS profile produced an initial flow profile that could be recalibrated over time to enhance water injection and reservoir management.

Flow distribution

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Distributed measurement acquisition systems

WellWatcher Ultra* and WellWatcher Ultra ASE* DTS acquisition systems generate high-resolution temperature logs over the life of a well. The latter dynamically corrects for signal loss due to fiber degradation at high temperatures. WellWatcher Hyperion* portable DTS acquisition system is suitable for remote and hostile environments. The hDVS system brings new high-performance capabilities to distributed acoustic sensing (DAS) while the DSTS system is used for distributed strain measurements.

Inductive coupler

Inductive couplers enable wireless power and bidirectional data transmission between the upper and lower completions. As a result, they facilitate deployment of permanent downhole measurement and control systems across the sandface. A high tolerance for debris and vibration makes these devices suitable for multistage deepwater completions, where intervention costs and risks are high.

Single-well and multwell acquisition units

These units provide a single common platform for monitoring and control of permanent downhole systems. They provide both onsite and remote data recording ability. WellWatcher SoloConn* single-well acquisition unit, WellWatcher Instruct* multwell acquisition unit, and WellWatcher ArConn* multwell rack-mountable acquisition unit can monitor up to 1, 4, and 16 wells, respectively.

Real-time data acquisition, downhole control, and data transmission

RTAC* real-time acquisition and control software and WellWatcher Connect* wellsite data transmission system enable remote collection and fast transmission of surface and downhole data. This encrypted data can be monitored through a secure web interface from any PC. RTAC software also provides control of downhole flow control valves.

Downhole dry-mate connectors

Field-proven Sealtite* downhole dry-mate and Intellitite* downhole dual-seal dry-mate connectors use metal-to-metal seals to provide reliable downhole electrical connections—even in the harshest conditions—by eliminating fluid ingress. Intellitite connectors feature redundant seals, which are independently tested at the wellsite using a microleak detection system; they also exhibit high tolerance to vibrations and shocks during installation and operation. A version of the Intellitite connector is also available for optical connections.

Surface and subsea interface cards

These devices communicate with downhole equipment via a proprietary communications protocol. They are compatible with IWIS and all vendor-specific control modules.
The extensive reservoir and production data obtained by WellWatcher system gauges and DTS systems provide a foundation for critical decision-making that helps operators enhance well diagnostics, reservoir performance, and, ultimately, production management. Schlumberger offers petrotechnical services to enhance the workflows available for WellWatcher permanent monitoring systems when you want support for your production management decisions.

- Production allocation
- Productivity analysis
- Inflow profiling
- Pressure transient analysis (PTA)
- Decline analysis
- Transient and thermal recovery analysis
- Completion integrity monitoring
- Skin evolution monitoring
- Intelligent completions management
- Artificial lift system optimization
- Riser temperature monitoring
- Opportunistic pressure buildup capture
- Enhanced bubblepoint and sanding pressure drawdown control
- Improved reservoir pressure history matching

Enhanced Production Management
Use data to make informed decisions

Pressure transient analysis
Early water breakthrough requires operators to balance choke adjustments with the stimulation treatment. WellWatcher Quartz gauges can be placed in a well to provide PTA workflows. These workflows reveal changes in skin and can be used to determine the productivity index (PI) of the well. Understanding the changes in PI enables operators to take the necessary steps to optimize production over the life of the well.

Unconventional well stimulation
Using WellWatcher Quartz Extend high-resolution dual-sensor PT gauges in unconventional oil and gas wells to monitor bottomhole pressure helps in identifying significant changes to skin, degradation of fracture size and conductivity, and stress-related permeability behaviors. Proactively analyzing the data enables operators to monitor drawdown during production and the health of the fractures, both of which are important for long-term well performance.

ESP management
Downhole pressure and temperature measurements obtained with WellWatcher Sapphire PT gauges can be combined with ESP surface parameters such as variable speed drive frequency to prevent deadheading, which often requires a costly workover and ESP replacement. The data can also be used to troubleshoot other common ESP scenarios such as scale deposition above the pump and loss of pump submergence.

Inflow profiling
In fields with stacked reservoirs, where pressure, permeability, and oil and gas characteristics vary greatly between layers, WellWatcher BriteBlue multimode DTS fiber can be run to provide inflow profiling of individual zones. Downhole flow control valves can then be used to manage individual zones independently without costly intervention.