Prototype testing indicate positive results for Secure Drilling Micro-Flux Control system

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AFTER THE INITIAL development phase using a computer simulator, the Secure Drilling Micro-Flux Control system was taken to Louisiana State University for field tests from October 2005 to March 2006. Both water- and oil-based muds were used, and many of the system's capabilities were tested using the 2 wells and natural gas injection of the facility. The results were all positive, and the system is now on its way to its first applications in real wells in Brazil and the US.

SYSTEM DESCRIPTION

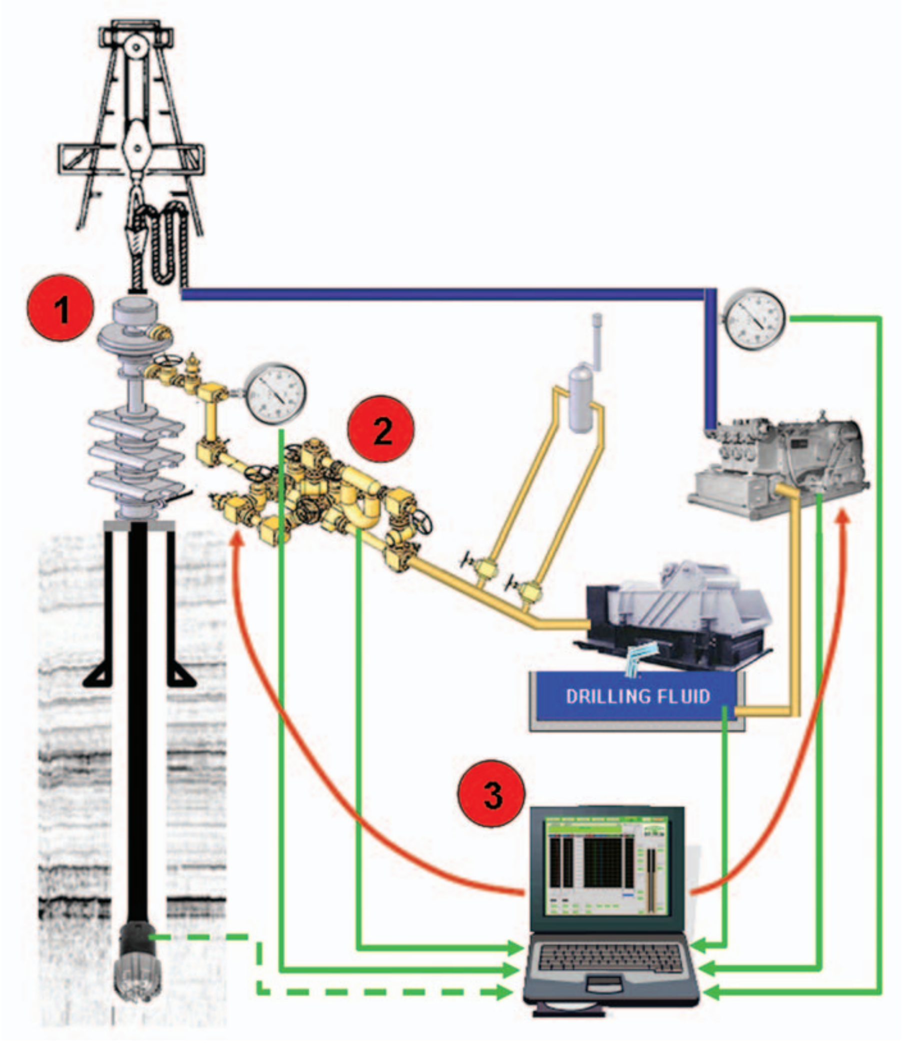
Secure Drilling is a new drilling method based on a closed-loop system and the Micro-Flux Control method. Unlike conventional drilling, in which the fluid return is open to the atmosphere, Secure Drilling uses a rotating control device to keep the well closed, and subsequently the fluid flows through a drilling choke manifold.

Because space on many rigs is very restricted, especially offshore, the system was developed so that all of the required equipment is integrated and compact. The current system has only one skid containing the chokes, flow meter, choke actuators and a data acquisition and control processor. In addition to the skid, there is a remote panel with a user interface that allows the driller to view what is going on and interact with the system. The system can be installed in virtually any onshore, jack-up or floating rig.

The Secure Drilling method uses as inputs:

- Flow rates in and out of the wellbore;
- Stand-pipe pressure;
- Surface back-pressure (measured upstream from the drilling choke); and
- The choke position.

Based on the flow and pressure data received and analyzed, the system detects any discrepancy between the expected and actual return flow, confirmed with pressure and flow measurements, identifying an influx or loss with very low volumes – around a few gallons in prototype testing at LSU.



A schematic of the Secure Drilling Micro-Flux Control System shows that a rotating control device is used to keep the well closed. The fluid subsequently flows through a drilling choke and manifold.

Once a small fluid gain or loss is detected, the system will immediately initiate actions, such as closing the chokes, to increase the bottomhole pressure of the well if an influx is detected, or displaying alert messages when the system has confirmed that a loss has occurred. The system has a central data acquisition and control system that collects and processes the data and directs the actions needed on the choke – opening or closing it – to react to the event and the actions desired.

The unique feature of the technology is its capability of measuring the return fluid flow using a flow meter installed just downstream of the chokes and its ability to detect and react to either a fluid gain or fluid loss in the very early stages. The immediate response from the system after a gain or loss is detected allows the volumes to be kept as small as possible – a micro-influx or micro-outflux.

KICK DETECTION

The first version of the system is the automatic kick detection and control system. In this application, the well is drilled normally using the rotating control head to divert the return flow to the choke manifold, and the choke is kept fully open. When a micro-influx is confirmed, the choke immediately starts to close and back-pressure increases so that the bottomhole pressure will increase until the flow out restores the same value as the flow in.

At this stage, the bottomhole pressure has equilibrated the formation pressure and the influx has been controlled. After this step, the system will automatically switch modes to circulate the influx out of the wellbore in a way very similar to traditional well-control techniques using the driller's method. During this mode, the method uses pressure control to keep the bottomhole pressure as constant as possible to the desired value to avoid taking secondary kicks while circulating the influx out of the wellbore. The system also displays to the driller the desired increase in mud weight needed to restore the same overbalanced condition present before the influx was taken.

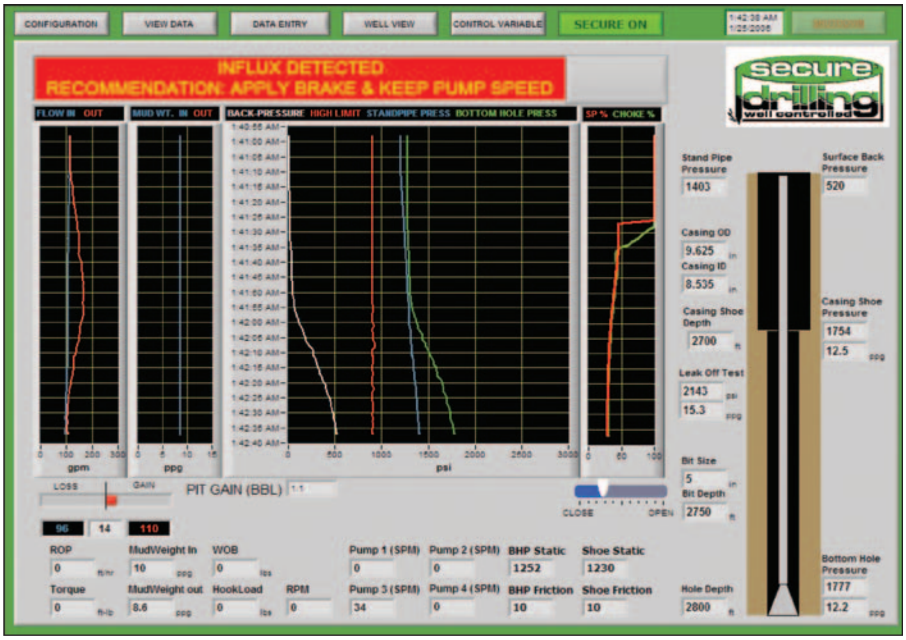
All these steps are done automatically using control technology, allowing the driller to merely monitor the screen to follow the events as they occur. If a fault or problem occurs, the driller can regain control of the well, switching the operation back to conventional well control or conventional drilling.

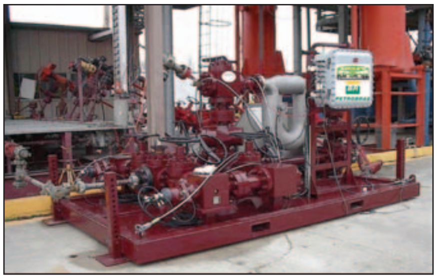
A fluid loss is also detectable by the system, but only an alert message is displayed so that the driller can take the necessary actions. As drilling is conducted with the choke fully open, there is no automatic action to be taken by the system to reduce the pressure inside the wellbore, to try to minimize the fluid loss event. But this alert message allows the rig crew to spot the problem in the very beginning.

TESTS OF PROTOTYPE

Full-scale tests were conducted with a full manifold using the Well Control Facility at LSU. The facility has 2 wells that simulate actual well conditions. The main goals of the tests were to demonstrate the capability of the system to detect and control influxes automatically and to confirm the volumes of influxes inside the wellbore.

The results showed that influxes were detected in less than 15 seconds (a few gallons) and the influxes were automatically controlled in less than 2 minutes. The final volume of influxes inside the wellbore was, in the worse case tested (900 psi underbalanced, equivalent to 7 ppg kick intensity factor), less than 2 bbl. In the tests, all the influxes were circulated out of the wellbore without getting a second influx. In all the tests with normal kick conditions, the total volumes of influxes were restricted to less than 1 bbl.





Above, a screen shot shows the basic screen of the system, displaying the flows in and out, mud weights in and out, the pressures, and well as the sketch of the downhole conditions, with the most important values for the driller to better understand what is happening downhole. Below, the Secure Drilling manifold is shown during field tests at Louisiana State University. The tests were conducted between October 2005 and March 2006.

OFFSHORE, COMPLICATED WELLS

The Secure Drilling technology can be used on virtually any rig due to the small footprint of the equipment and the need for no sophisticated data. While the system will be more accurate with more inputs, even using just the basic surface data of flow in and out and stand pipe and back-pressure, it has already proved to be accurate. Wells can be drilled conventionally, and Secure Drilling may be used only in the critical sections where the risk of kicks and blow-outs is high, or it can be used throughout the well. With the equipment at the rig and the return from the rotating control device connected to the manifold, the only action required to activate the system is to install the bearing assembly of the rotating control device and to divert the flow to the choke manifold. Restoration of conventional drilling requires only the removal of the bearing assembly and returning flow to the standard flow line. The system can be used at anytime after the BOP stack has been installed.

Most wells will benefit from using the system, but challenging wells, including deepwater and ultra-deepwater wells, will realize the most significant benefits. Other extreme applications include: HPHT wells; exploratory wells with unknown pore-pressures; narrow margin wells; wells with zones having rapid changes in pore-pressure; H_2S wells; infield drilling where steam injection is employed; fields with numerous well-control incidents; environmentally sensitive areas where blow-out risks must be reduced; slim-hole wells; wells that are drilled with casing; and wells that are drilled in hydrate areas.

BREAKTHROUGHS

Based on the tests conducted at LSU so far, using both water- and oil-based muds, as well as testing influxes, losses, HPHT conditions, and leak-off tests simulations, a few breakthroughs can be anticipated to be seen and confirmed when wells are drilled with the system:

- Unprecedented and unparalleled kick and loss detection capability – typically less than 0.5 bbl;
- Very small volume of kick inside the

wellbore < 5 bbl;

• Very quick detection and control of the influx < 2 minutes;

• All the above applies to gas kicks in both water- and oil-based muds;

• All the above applies to fixed rigs as well as to floaters (deep and ultra-deep waters).

INDUSTRY IMPACT

Secure Drilling will have a significant impact in the drilling industry in 3 important ways: safety, well design and costs.

Safety: The system provides a revolutionary method of detecting and automatically controlling and circulating out influxes in a wellbore. Early detection will substantially reduce the risk of blowouts, even when kicks are encountered at shallow depths, where very fast action in detection and control is required.

Well design: The technology will allow for wells to be designed to take advantage of the greater ability to drill within kick tolerances. Many wells are interrupted because they do not have a safety margin to drill ahead. Exceptions in the safety guidelines must be made to allow these wells to proceed, significantly increasing the risks. Kick volumes of 25, 35 and even 50 bbl are commonly used for these calculations.

The system allows the volumes for calculating the safety margins to be reduced to less than 5 bbl. As a result, well design can be optimized, and casing strings may be set at different depths and, in some cases, one or more casing strings may be eliminated.

In addition, wells are typically designed using predicted pore and fracture pressure curves. There can be large discrepancies between predictive and observed values obtained when drilling is under way. Secure Drilling will allow deviations from the expected values to be immediately detected and controlled.

Cost Savings: Secure Drilling will have a large impact on costs. One study conducted in shallow water in the Gulf of Mexico showed that more than 30% of nonproductive time could be reduced by using the system. This figure will be higher in areas with very complicated pore-pressure behavior and geological environments. Reduction in side-track costs and the potential elimination of casing strings as noted above also presents large cost savings potential. ■