

Well control advances meet new drilling demands

ADVANCED TECHNOLOGY, sophisticated equipment and rigorous crew training are the tools the drilling industry uses to maintain control of the well while drilling. Together they have brought dramatic improvement.

But a recent increase in the number of incidents of loss of well control in the Gulf of Mexico, for example, is a reminder that the well control challenge is ever present.

As one of industry's top priorities, well control is the focus of two sessions at the 2002 IADC/SPE Drilling Conference in Dallas.

Both sessions are to be co-chaired by **M R Plaisance**, **Diamond Offshore Drilling Inc** and **M E Rolleg**, **Santa Fe Snyder Corp.**

METHOD FIELD TESTED

Deepwater well control with a subsea BOP is often difficult and in many circumstances impossible with the usual methods and procedures. This is due mainly to the difficulty in maintaining the circulating pressure below the low formation fracture pressure because of high friction losses in kill and choke lines. Such a situation often leads to loss of the drilled section.

In IADC/SPE paper 74470, "Off Setting Kill and Choke Lines Friction Losses for Deepwater Well Control: The Field Test," the authors report on a recent test of a method for lightening the mud column inside the choke line by injecting base oil or water at the BOP level.

P Isambourg, **A Simondon** and **R Studer**, **TotalFinaElf**, prepared the paper for the Conference.

To validate simulations and to confirm the operational feasibility of this method, a field test was conducted on a deepwater well in Angola. Pressures recorded at surface, BOP and bottom hole levels confirmed predicted values. The test was performed without any modification of the drilling rig, and no operational problems were encountered.

According to the authors, the test fully confirmed that the method allows the physical removal of friction losses in the



Field test of method to lighten mud column in choke line was conducted on a deepwater well in Angola using this drillship. Goal was to validate simulations and to confirm operational feasibility.

choke lines. The downhole pressure during a well control operation is then lowered compared to a conventional method in all cases where the choke line friction losses cannot be removed artificially at the choke.

SUBSEA ACCUMULATORS

Blowout preventer (BOP) hydraulic control systems have long used accumulator bottles to deliver energy to operate equipment more quickly than the pumps can alone.

With the advent of subsea stacks, it was recognized that these accumulators and the operating procedure needed to be modified to reflect the effects of hydrostatic head. The continued expansion into deeper waters, coupled with an increase in the system operating pressure for the latest generation rigs, has brought new methods of calculating the energy available in subsea accumulators.

In IADC/SPE paper 74469, "Deepwater BOP Subsea Hydraulic Accumulator Energy Availability—How to Ensure You Have What You Need," author **J P Sattler**, **West Hou Inc**, reviews accumulator calculations and makes operating recommendations.

Traditional accumulator calculations and regulatory standards assume

isothermal (constant temperature) ideal gas behavior. Operating in deeper water and advances in shearing requirements and tubular strength affects the pressure required to operate BOPs, the author notes.

At the same time, API standards committees recognized the inaccuracies associated with these assumptions, and provided adequate safety factors in their standards to compensate.

However, there are no guidelines at this time for how much energy is to be maintained in subsea accumulators.

The author reviews the impact of subsea accumulators on fifth generation floating drilling rig BOP operation, energy requirements such accumulators must deliver, and different ways of calculating that energy.

PREDICTIVE TESTING

IADC/SPE paper 74471, "Using Predictive Testing to Circumvent Blowout Prevention Equipment Downtime," outlines predictive tests, describes the principles upon which the tests are based, and shows where they have identified pending failure.

The paper was prepared for the Conference by **M E Montgomery**, **West Hou Inc.**

Pulling the blowout preventer (BOP) stack or Lower Marine Riser Package (LMRP) on a floating drilling rig has always been costly. However, when operating in the ultradeepwater theater, those costs regularly exceed \$1 million.

As a result, notes the author, developing and utilizing methods to ensure operative BOP equipment and systems continues to grow in importance.

The first known field predictive test on BOPs was conducted on ram locking systems in the North Sea in 1987. Since that time, the tests have been refined to identify other modes of failure so they can be corrected while on the surface, providing increased assurance of their ability to function when they are needed on the wellhead.

Additionally, notes the author, predictive tests have been devised and their effectiveness demonstrated on ram locking systems, connectors, annulars, failsafe valves and control systems.

SHALLOW GEOHAZARDS

IADC/SPE paper 74481, "Shallow Geohazard Risk Mitigation—A Drilling Contractor's Perspective," examines the consequences of shallow geohazard events and outlines ways to lower risk. **D R Reed, Santa Fe Techserv (North Sea)**, prepared the paper for the Drilling Conference.

The Safety Case Regime 1992 and the Design and Construction Regulations 1996 for offshore operations in the UK North Sea require well-related risks to be kept As Low As Reasonably Practicable (ALARP).

The responsibility of the rig owner in this regime is clearly to identify safety critical elements associated with the rig and ensure that these risks are maintained to within ALARP principles.

It is also recognized that the wellbore attached to the rig may also present a threat to the installation and those onboard. The rig owner must also take into account these well-related safety critical elements.

The exposure of the installation and personnel during a shallow geohazard incident is high and response options limited, notes the author.

Therefore it is important that the drilling contractor understands the geo-

hazard risks specific to each well or surface location and how those risks are interpreted.

The author reviews the process of producing a site survey and shows how implementation of a Shallow Geohazard Review Process has reduced risk.

ASSURING SMD SAFETY

One tool used to assure that the Well Control Team that was part of the Subsea Mudlift Drilling Joint Industry Project met its goal was the HAZOP process.

In IADC/SPE paper 74482, "HAZOP of Well Control Procedures Provides Assurance of the Safety of the SubSea MudLift Drilling System," the authors describe the HAZOP process.

The paper was prepared for the Conference by **J J Schubert and H C Juykam-Wold, Texas A & M University; C E Weddle, Cherokee Offshore Engineering; and C H Alexander, Consultant.**

To meet the challenges of drilling in intermediate and ultradeep waters (greater than 5,000 ft), a drilling technique referred to as dual gradient drilling is being developed and tested by 4 industry projects.

These projects are being conducted by the SubSea MudLift Drilling (SMD) JIP, the DeepVision JIP, **Shell Oil Company**, and **Maurer Technology**.

The first 3 achieve dual gradient by placing pumps at or near the seafloor to lift the drilling fluid and cuttings from the well annulus to the surface via a return line.

The fourth project proposes the injection of hollow glass spheres into the riser near the mudline.

All 4 projects must address well control issues affected by the dual pressure gradient imposed by the drilling fluid, the possible U-tube that is associated with the dual gradient systems, and the equipment that is being designed for each individual project.

Very early in the SMD JIP, well control techniques for dual gradient drilling were identified as a key success factor in the project, according to the authors.

The goal was to develop a well control program that was at least as safe, if not safer, than the current practices.

OFF BOTTOM KILL

Despite success from improved technology and training, blowouts and underground blowouts still happen.

Frequently, these events occur when the drill pipe is partially removed from the well, preventing use of conventional blowout prevention procedures. At other times, these events damage the drill pipe, preventing its use for conventional control methods.

These situations require the use of "off-bottom" well control procedures, according to the authors of IADC/SPE alternate paper 74568, "Experimental Evaluation of Control Fluid Fallback During Off-Bottom Well Control."

The paper was prepared for the Drilling Conference by **F S Flores-Avila and J R Smith, Louisiana State University; and A T Burgoyne and D A Burgoyne, Bourgoyne Enterprises Inc.**

Rigorous engineering design and analysis methods for off-bottom kill procedures have never been developed, note the authors.

For the specific case of the off-bottom dynamic kill, the tendency for the dense kill fluid to fall through, and flow counter-current to, the formation fluid out of the well can provide a means of killing the well even if the typical design criteria cannot be met. However, this counter-current flow process is poorly understood, and no design or prediction methods currently exist for a kill procedure using this concept.

Full-scale experiments were performed with natural gas and water based drilling fluid in a 2,800-ft deep research well to measure liquid accumulation during blowout conditions. Counter-current flow of kill fluid through formation fluid flowing upwards in a blowout well, and its relation to the dynamic kill method, was studied.

A solution approach to the problem of evaluating the amount of liquid that flows countercurrent into, and accumulates in, the well based on the concept of zero net liquid flow (ZNLf) holdup is presented.

This solution is validated with the experimental data and provides a means for predicting the effect of liquid fallback during an off-bottom dynamic kill, the authors report. ■