First dual gradient drilling system set for field test

John Kennedy, Contributing Editor

AS MORE WELLS ARE DRILLED in water depths of 2,000 m and more, dealing with the slim margin between pore pressure and fracture gradient becomes increasingly important.

Understanding pressure relationships and applying proper equipment and procedures are critical to ensuring borehole stability and well control.

Several multi-company projects and development efforts by individual companies are aimed at effectively meeting the ultra deepwater pore pressure/frac gradient challenge.

THE SMD JIP

Work on developing dual gradient systems and techniques accelerated in the mid-1990s when a joint industry project (JIP) was begun with the goal of delivering a dual-gradient drilling technology for use in high-pressure, low-fracture-gradient, ultra deepwater environments.

Almost exactly 5 years later, the new technology—SubSea MudLift Drilling (SMD)—is preparing to spud the world's first dual gradient well. The field test is taking place in relatively shallow waters—1,000 ft—in order to test the SMD components in a drilling environment and evaluate drilling procedures.

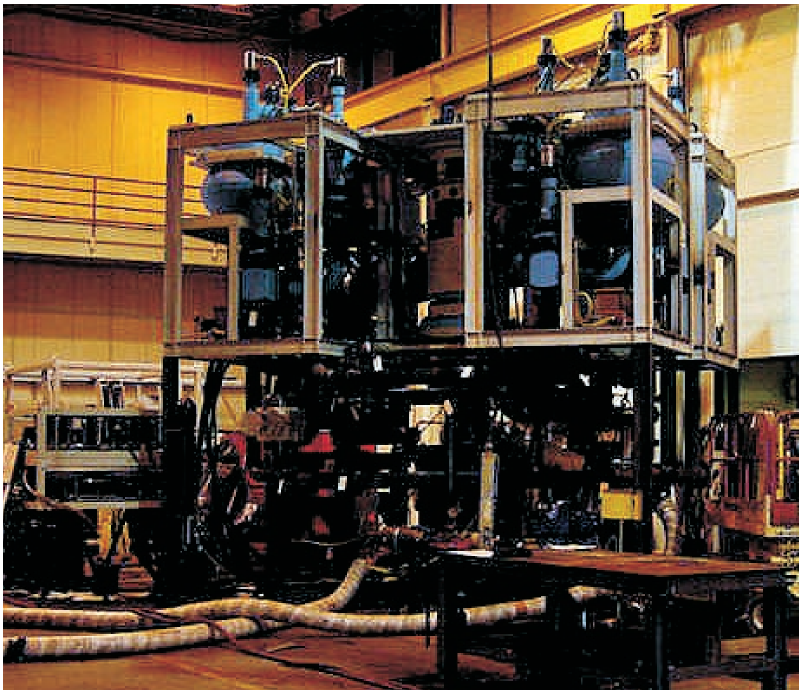
What is learned in this test will be integrated into the commercial system design and the operational and well control procedures.

The JIP's goal is to deliver this commercially available system to the participants by late 2002. Included in this "deliverable" is complete training and support to help use the system safely and efficiently.

"This is enabling technology," said **Ken Smith**, **Conoco**, Project Manager for the SubSea MudLift Drilling JIP.

"Without it, industry simply will not develop many of the reserves found in deepwater environments."

The Phase III test of components now under way will take place on the **Diamond Offshore Drilling Inc** semisubmersible Ocean New Era in a **Texaco** producing field in the Gulf of Mexico's Green Canyon area. Diamond Offshore Drilling and Texaco are the field test contractor and operator. In addition to these and project leader Conoco, participants in the project include **BP**, **Global Marine Drilling Co**, **Hydril Co**, **Schlumberger** and **Chevron**.



SubSea MudLift Drilling (SMD) field test system shown here undergoing factory acceptance testing will soon begin its field trial in the Gulf of Mexico in about 1,000 ft of water.

The 100,000-lb SubSea MudLift test system, which attaches directly to the BOP, was built at Hydril's Houston plant.

While the need for new technology was obvious when the JIP was established, the cost to develop it has been significant. Estimated cost for the 3 phases of the JIP—from conceptual engineering to delivery of a commercial system—is about $45 million.

"But the SMD JIP is just the beginning. This new technology will evolve into other applications and bring additional savings," said Mr Smith.

"Dual-gradient drilling will help realize the potential of deep water exploration and development."

THE CHALLENGE

Despite the investment in drilling rigs that can operate in water depths to 8,000 ft or more, much of the potential oil and gas resource in reservoirs at these depths cannot be developed without new ways to lower hydrostatic mud pressures to prevent fracturing in shallow zones.

Ultradeep water drilling poses several problems, including shallow water flows, lost circulation and lost of well control. Any of these may prevent a well objective from being reached.

To avoid these problems, it has been necessary to run multiple casing strings. That means that the production string may be too small for high rate wells and for horizontal or multilateral completions that might be necessary to make a discovery economic. "The small margin between pore pressure and fracture gradients is at the root of these problems," said Mr Smith.

In conventional drilling, pore pressure is controlled by a column of mud from the bottom of the well to the rig. In dual gradient drilling, the mud column extends only from the bottom of the hole to the mudline. A column of seawater that exerts a lower hydrostatic head then extends from the mudline to the rig.

Dual gradient techniques use a pump or other method to reduce the hydrostatic head from the mudline to the surface to that of seawater. Because of this, the balanced U-tube that is present in con-

The seawater filter skid is used to clean the seawater power fluid prior to pumping it subsea. Seawater powers the SMD system subsea pump.

ventional drilling is not present in dual gradient drilling.

A drill string valve (DSV) is used to control this imbalance when the mud pumps are shut down.

DUAL GRADIENT ADVANTAGES

The dual gradient approach offers several advantages over conventional drilling in very deep water.

Because pore, fracture and mud pressure gradients are referenced to the mudline instead of the rig, dual gradient drilling increases the margin between pore pressure and fracture gradient. That, in turn, offers key benefits:

• It is possible to reduce the number of casing strings;

• A larger completion string provides increased flow capacity;

• Riser margin is in place at all times so disconnect well control hazards are reduced;

• Drilling efficiency and mechanical risk are improved, lowering well costs.

The system developed by the SMD JIP lets an operator drill extended reach wells with multilateral extensions and arrive at TD with 9⅝-in. casing in 10,000 ft of water and beyond. It is possible to eliminate as many as 4 casing strings.

Drilling efficiency and safety is increased because well kicks and lost circulation problems are reduced and less rig "trouble time" will be experienced.

"In an ultra-deepwater well, the savings could range from $5-15 million in casing running alone.

"Also, the mechanical risk associated with these wells today is greatly diminished, resulting in further savings," said Mr Smith.

Eliminating the mud from the riser also reduces riser-tensioning loads. That potentially increases the water depth capability of the rig.

SMD COMPONENTS

The system developed by the SMD JIP that is now under test includes these key components: A Drill String Valve (DSV), the SubSea Rotating Diverter (SRD) and the SubSea MudLift Pump.

The diverter and pump are both part of the SubSea MudLift Module.

The DSV was developed because when circulation stopped, the U-tube imbalance could equalize at high rates for several minutes, masking other potential problems such as well flows or lost returns.

The DSV is a pressure-balanced drill pipe float with a large spring that is run at or near the bit. Its opening pressure is adjustable from the rig.

When mud flowing up the annulus reaches the mudline where it normally would enter the riser, return flow is diverted from the annulus to the SubSea MudLift Module located at the mudline.

The diverter in the subsea module diverts return mud from the riser base to the subsea pump suction.

The diverter can handle 6⅝-in., 5½-in. and 5-in. drill pipe and has a retrievable rotating seal rated for 500 psi. Ordinarily, the differential pressure across this seal is less than 50 psi.

The MudLift pump acts as a check valve, preventing the hydrostatic pressure of the mud in the return lines from being transmitted back to the wellbore.

The positive displacement pump unit is powered by seawater, which is pumped from the rig using conventional mud pumps down an auxiliary line attached to the marine riser.

The cuttings-laden mud, as well as any other well fluids, will be returned to the rig via another line attached to the riser.

The MudLift pump will normally be run in an automatic mode, responding to pressure conditions it senses in the well.

So the driller can operate the surface mud pumps much as is done in conventional drilling.

The basic MudLift system can be configured to make it compatible with different rigs.

TRAINING REQUIREMENTS

Dual gradient drilling is somewhat more complicated than conventional operations, said Mr Smith.

"Significant re-education and additional training will be necessary," he said. "It is not a formidable obstacle, but it does require a change of mindset."

The key concept is effective management of the U-tube.

Some examples help illustrate the differences:

• The DSV keeps circulating procedures similar to those of conventional drilling, but the valve is not used when running casing so cementing procedures must be revised;

• The DSV, though it makes operations seem familiar, is not critical to well control;

• Tripping out of the hole requires two trip tanks—one for mud and one for seawater;

• Kicks can be circulated out at almost any flow rate;

• Bottomhole pressure can be varied by adding barite or raising the mud/seawater interface in the riser.

"MudLift drilling, in most cases, enhances kick detection and well killing operations," said Mr Smith.

"A true riser margin is always in place because mud weight in the wellbore below the mudline is always high enough to overbalance wellbore pore pressure."

THE JIP

The joint industry project comprises 3 phases. The first phase, an investigation of ways to manage hydrostatic pressures, involved 22 drilling contractors and operators from Europe, North America and South America.

In that phase, the group agreed on the equipment configuration and determined that both well control and routine drilling operations were possible.

Phase II, begun in early 1998, focused on developing, building and testing critical system components. It involved 4 operators, 4 contractors and 1 manufacturer. Well control procedures were also developed during this phase.

Phase III involves the current field testing. Assuming success, the result of this testing will lead to a commercially available system as early as late in 2002.

Though there is no "Phase IV," this JIP is providing the first step of what may be a long trail of product and technology evolution.

The Drill String Valve (DSV) was tested extensively with abrasive fluids in the shop prior to field use. The DSV, a pressure balanced drill pipe float, is run at or near the bit.

"We believe that SMD technology will evolve, filling needs such as top hole drilling, drilling from floating platforms, underbalanced drilling and many other areas," said Mr Smith.

"We are just taking the first steps now."

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