Surface BOP proves to be efficient drilling technique

Pat Ryan, Unocal

THE RECENT CONVERSION of the **Diamond Offshore** "Ocean Baroness" from a conventional subsea BOP to surface BOP (SBOP) marks the fourth semisubmersible drilling rig conversion by **Unocal Corporation** since 1996. This article will give a broad overview of why Unocal advanced the development of SBOP's for use on floaters, a description of the system, risk management, operational statistics, and finally a case history of a specific well.

HISTORY

In the early 1990s Unocal Indonesia's East Kalimantan operations were at a mature state of exploitation. Production was in decline and commodity prices were generally flat. The business unit had historically low exploration success and was seriously evaluating divestiture. Development well costs, however, were falling due to a focused effort on performance. These circumstances spawned the question, could local conditions, knowledge and ability to reduce development well costs be used in exploration to add value and spark growth?

Unocal Indonesia, like many other companies, had a fixed annual exploration budget. When this capital was used to drill conventional subsea exploration wells, only six or seven prospects per year could be evaluated, assuming water depths less than 1,500 ft drilling rigs for deeper water required significant mobilization costs. In addition, owing to the exploration maturity of the area, only the higher risk, subtle exploration opportunities remained undrilled. It was essential that more prospects be drilled to increase the statistical opportunity for success.

The East Kalimantan team believed growth was possible, but not by conventional methods. A new philosophy had to be developed, centered on the specific problem of high exploration risk in a proven, prolific hydrocarbon province. The efforts to solve this problem produced the Saturation Exploration (SX) strategy. The SX strategy was to drill as many prospects as possible, thus increasing the statistical opportunity for success. Key to this effort was to minimize the time spent on each well, thus reducing costs. With low exploration well costs, a higher degree of prospect risk could be tolerated. Essentially, the exploration strategy defined the drilling system.

An optimized well design was needed to minimize well time and costs. Slimmer casing oriented around expendable wellbores meant a savings in time and costs.

Additionally, an intensive evaluation of data collection needs was conducted. It was found that with minimal exploration penetrations, the team tended to maximize the amount of data collected. By committing to only necessary data collection, rationalizing wants versus needs, the evaluation portion of the drilling capital spent on obvious dry holes could be minimized, and the money saved used for evaluation of other prospects.

It was recognized that the only way to effectively execute the SX strategy was to go beyond the traditional assembly line interaction of discipline-based teams. The cross-functional SX team was formed, consisting of members that included geologists, geophysicists, drillers, and uniquely, management. All operational decisions, such as data collection, TD, P&A and prospect drilling order, were kept at the team level. All team members had equal standing and responsibility. The team was empowered to make critical decisions, but also was held accountable for results.

A significant factor of the SX strategy's success was to design the complete operation as a system as opposed to the traditional interaction of discrete elements. In support of this, the cross-functional SX team was soon expanded to include the contractors that provided the operational support. Active involvement of the drilling contractor, mud loggers, LWD and electric line logging personnel proved paramount.

SYSTEM DESCRIPTION

Just as the team was optimized to support low well costs, it was recognized that the drilling system needed critical evaluation. It was found that with subsea operations, a significant amount of time was spent in support of the installation of the subsea BOP and riser. A paradigm shift was needed.

When the use of a SBOP on a semisubmersible was first introduced, it raised many eyebrows within Unocal's drilling community, but as concerns were identified, they were evaluated, risked and mitigated. There was a significant effort required prior to the first SBOP installation, which may never be fully appreciated. Unocal recognized very early that while much of the expertise to develop this system was available within the company, there were many specialized areas that were not. Unocal sought and retained experts to support the development and qualification of the riser, riser connections and mooring system. Outside experts were also enlisted to help in understanding the local meteorologi-

The recent conversion of Diamond Offshore's Ocean Baroness from a conventional subsea BOP to surface BOP configuration marks the fourth semisubmersible conversion by Unocal since 1996.

cal and oceanographic conditions. The cycle of design, analysis, risk assessment, mitigation, execution, evaluation, and finally re-design is still functioning today, and many of the experts first retained are still supporting the project. This process has advanced the use of the SBOP system on various semisubmersibles from 70 ft of water to 6,722 ft of water. There have been approximately 70 man-years of effort in support of this technology.

Both 18 ¾-in. and 13 ⅝-in. BOP stacks have been used over the last seven years. The original SBOP was an 18 ¾" BOP supported from above by a sheaves/wire configuration attached to a conventional riser tensioning system. This SBOP arrangement was two 10,000 psi doubles and a 5,000 psi annular connected to a subsea wellhead via a hydraulic connector. A slip joint was installed to connect the annular to the diverter housing.

With this system in the centerline of the rotary, a 17 ½-in. riserless hole section was drilled while rotating through the SBOP and wellhead. Once the 17 ½-in. BHA was retrieved, 13 ⅜-in. casing would be run and landed in the wellhead via a standard wellhead hanger. The casing was then cemented in place, running tool retrieved and hanger packoff installed and tested. Drilling to TD would then proceed. When the well reached TD, logged and P&A'd, the 13 ⅜-in. casing was cut at the mudline by using a standard casing cutter and retrieved.

As the system progressed to deeper water, the method of supporting the SBOP and riser from the top of the SBOP began to near its limits due to the amount of tension that could be carried through the stack. This led to the design of a wellhead support frame. This configuration involved the same sheave/wire system but connected to the wellhead support frame (WHSF) that again attached to conventional riser tensioners. With the WHSF in the centerline of the rotary, the 17 ½-in. riserless hole section was drilled. After the 17 ½-in. BHA was retrieved, 13 ⅜-in. casing would be run, attaching a 13 ⅝-in. Unihead with an external landing ring to the top joint of casing. This assembly was lowered and landed in the WHSF, the 13 ⅜-in. casing was then cemented and the wellhead running tool released. A 13 ⅝-in. SBOP, consisting of one 10,000 psi double, one 10,000 psi single and a 5,000 psi annular, was moved into place via overhead bridge cranes and connected to the wellhead with a hydraulic connector. As before, a slip joint would be installed to connect the SBOP to the diverter housing and the SBOP and casing tested.

Again, as the system was needed in increasing water depths, the capacity of the conventional riser tensioning system began to limit the overall system. This requirement led to the development of the system currently in use on the Ocean Baroness. This system uses an 18 ¾-in. SBOP attached to a conventional subsea wellhead. The subsea wellhead is landed in a WHSF via a 30-in. low-pressure housing that is welded directly to the WHSF. The weight of the riser, wellhead support frame and SBOP are conveyed to the rig via the use of direct acting tensioners. With this configuration in the centerline of the rotary, a 17 ½-in. riserless hole section is drilled while rotating through the SBOP and wellhead. Once the 17 ½-in. BHA is retrieved, 13 ⅜-in. casing is run and landed in the wellhead via a custom designed wellhead hanger stress joint. The casing is then cemented in place, running tool retrieved and hanger pack-off installed and tested.

ENVIRONMENTAL CONDITIONS

Simply installing a BOP in the moon pool of a floating drilling rig is not an accurate description of the total SBOP system. Having the ability to monitor and manage the forces of tension, bending and acceleration on the riser has proven to be invaluable. Unocal has developed a system of strain gauges and accelerometers strategically placed directly on the riser. These instruments monitor the forces, in real time, that are produced by vortex-induced and drilling-induced vibrations, as well as the effective tension just below the wellhead and at the mudline. With this information, operational guidelines have been developed to allow rig personnel to take the necessary action to prevent riser damage.

In reality, the use of a SBOP on a semi-submersible is not much different than the BOP configuration on a jackup. The main difference is that a jackup is fixed in place, while a semisubmersible will move with heave, tide, current and wind. In essence, the successful use of a SBOP on a semisubmersible is directly proportional to the specific meteorological and oceanographic conditions in the area of use and the efficiency of the mooring system.

Unocal Indonesia's area of operation has the advantage of being located very near the Equator, protected from severe meteorological and oceanographic conditions by the islands of Borneo to the west and Sulawesi to the east. High currents have been the largest concern.

To understand the regional currents, a series of bottom-founded current meters were placed throughout the area to collect this data. These meters have been installed for a few months up to a number of years. As an area is evaluated for SBOP use, such as the South Sulu Sea and the Southern Andaman Sea, current meters are installed and data collected. In-house mooring specialists then use the data to qualify the SBOP system for use.

MOORING SYSTEM

Understanding the mooring system cannot be underestimated. Unocal has used its unique experience and requirements to develop a pre-laid mooring system. With nearly continuous drilling, it is possible to have the moorings on the second well installed and anchors tested. Once the first well is P&A'd, the mooring system is disconnected while the riser is being retrieved. The rig is then towed to the second location and the riserless BHA run to seabed while the rig is being connected to the pre-laid system. After the connections are made, and pre-tension performed, the well is spudded without delay. While the second well is being drilled, the anchor handling vessels are released to retrieve the prior system and begin the next pre-lay cycle.

Additionally, Unocal has employed the use of a semi-taut mooring system on wells in water depths greater than 5,000 ft. This system uses high strength mooring lines in conjunction with Drag Embedment Normal Lay Anchors. A semi-taut system has the advantage of allowing less offset, as the lateral motion of the rig is restrained by the tension transmitted to the anchors via the high strength mooring lines. A traditional centenary system uses the dead weight of the mooring system to provide the reactionary force to lateral movement, thus producing larger offsets for a given set of meteorological and oceanographic conditions.

SUBSEA BOP CASE HISTORY

The following is a description of the operational steps involved on a representative well in 6,722 ft of water with the associated time for each element.

Attach rig to pre-laid mooring system in 6,722′ water	24.0 hours
Pre-tension anchors and conduct pre-spud operations	10.5 hours
Drill and condition 17-1/2″ hole to 9,214′ MD	17.0 hours
Run and cement 13-3/8″ casing, install BOP & test and conduct LOT	23.5 hours
Drill 12-1/4″ x 14-3/4″ bi-centered hole to 10,526′ MD	39.6 hours
Run and cement 11-3/4″ liner, test and conduct LOT	19.4 hours
Drill 10-5/8″ x 12-1/4″ bi-centered hole to 12,977′ MD	77.0 hours
Run and cement 9-5/8″ liner, test and conduct LOT	23.0 hours
Drill 8-1/2″ hole to 14,187′ MD	43.9 hours
Run and cement 7″ liner, test and conduct LOT	19.9 hours
Drill 6-1/8″ hole to 16,048′ MD	49.4 hours
Log 6-1/8″ hole	7.9 hours
Plug and abandon well	28.6 hours
Disconnect from pre-laid mooring system	44.4 hours
Total time on well	17.8 days

RISK MANAGEMENT

Use of any system within our industry contains an element of risk, but success is directly related to one's ability to effectively manage that risk. Unocal uses a process that first attempts to identify all risks associated with the system or project. Once identified, these risks are ranked for frequency and severity.

All risks that are classified as moderate to high must either be eliminated, or, if that is not possible, mitigated to such an extent that it falls into the low risk category. This process was used throughout the development of the SBOP.

Risk management did not stop once the SBOP was installed and commissioned. It is an on-going process that still affects nearly every decision on every well. The SX team begins the risk management process months prior to well spud. Issues relating to shoe placement considering shallow hazards, fluid type, column height, and pressure regimes are discussed and team consensus formed.

Additionally, Unocal has developed standard operating guidelines and procedures that address well design, kick tolerance, pressure testing, and operating parameters. If a well is foreseen to operate outside of these pre-determined limits, an additional process to manage that change then takes effect.

As mentioned previously, success is directly related to the ability to manage risk. In a study by SINTEF (SPE 66186) 7,200 subsea BOP days were considered in water depths greater than 1,312 ft. Unocal has analyzed this data and determined that 31 BOP failures occurred that had the potential for uncontrolled flow. This translates to 4.1 incidents per 1,000 BOP days.

In comparison, Unocal has recorded four incidents that had the potential for uncontrolled flow over 1,360 BOP days. This yields 2.9 incidents per 1,000 BOP days.

Unocal believes no incident is acceptable. The lessons learned from each of the four incidents have provided a wealth of information to further enhance the continued safe and effective use of the SBOP system within our operations.

OPERATIONAL STATISTICS

Mark Twain suggested there are "lies, damn lies and statistics". With this in mind, following are only a few statistics presented to demonstrate the level of commitment Unocal has made to the use of surface BOP in the appropriate areas.

Unocal Indonesia has drilled 139 wells in 2,182 rig days, from 1996 through the 2002 drilling program, in water depths ranging from 70 ft to 6,722 ft. An additional five wells were drilled by Unocal Thailand in about 3,000 ft of water.

The total well costs including logging, testing and tangibles were approximately $410,000,000 for the 139 Unocal Indonesia wells. The average water depth over the 139 wells was 3,250 ft. Tage days per well was 15.7.

SUMMARY

To date, a number of operators have embraced the use of surface BOPS on floating drilling structures. They include **ConocoPhillips** in China, **Santos** in Indonesia, and **Shell** in both Brunei and Brazil, to name a few.

While the specific reason for using SBOP technology has varied for each operator, the common factor in each case is that the use of the SBOP on a floating drilling structure has provided a safe and efficient approach in support of their objectives.

Over the past seven years, Unocal has become the clear leader in the application of SBOP systems for use on floating drilling rigs, drilling 139 wells.

The use of SBOP's for exploration within Unocal Indonesia has transformed a mature producing asset to the leading growth area within the company.

These results have been produced not simply with the installation of a SBOP in the moon pool of a semisubmersible, but rather with the formation of a unique exploration strategy and a truly functional multi-disciplinary team of highly dedicated professionals. These professionals have committed decades of man-years to the design, analysis, improvement and risk management of the SBOP system that is currently yielding world-class drilling results. ■