Training, control ensure success of offshore underbalanced drilling

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THE SANTA FE INTERNATIONAL jackup drilling unit Britannia has been used successfully for three years by **Shell UK Exploration & Production** in the southern North Sea to drill a series of underbalanced wells, the first such wells from an offshore rig.

Standard underbalanced drilling tools and techniques do not lend themselves directly to an offshore rig operation and have required considerable engineering.

The overriding need to ensure safety of personnel in a new and untried operating environment required additional hardware, training, and the integration of new personnel into the offshore team.

The vast experience base and commitment of the Britannia's drilling crew, specificall, in the areas of multilateral extended reach (ERD) wells in the southern North sea, played a key role in the success of the project.

The type D-221 jackup, built in the UK in 1968, is the only one of its kind. The four legged jackup design is unique and has the added advantage of a large usable deck space area, nearly double that available on an MLT 116C rig design.

At the time of the underbalanced drilling (UBD) implementation, large deck space was a significant selection factor, as much of the equipment was a derivative from land based operations and not for an offshore environment.

UBD PREPARATION

A Shell Expro/Santa Fe interface document was prepared and included a UBD supplement outlining planned operations, showing that safety would not be compromised with as low as reasonably practical (ALARP) risk to personnel. The contents included:

- The arrangements for carrying out underbalanced drilling, and a process definition and summary of the plant required to implement the UBD process;
- The new hazards generated on the rig as a result of the technique;
- The risks on the rig specifically associated with UBD;
- The controls to be implemented to adequately manage the hazards in terms of prevention or achievement of ALARP principles.

A large usable deck space area was a key advantage when outfitting the Brittania for underbalanced drilling in the North sea.

RIG SPECIFIC ISSUES

In preparation for the underbalanced program, these rig specific issues were addressed:

- Structural loading considerations;
- Rig stability for higher air gap;
- Access/egress due to additional equipment;
- Additional lighting for areas not normally used;
- Hazardous area re-classification;
- Certification of all new plant components by rig verification authority;
- Review fire and gas Detection (FEA);
- Radiation survey for anticipated flaring operations;
- Additional noise hazard assessment of noise caused by extra generating equipment and high flare rates.

PERSONNEL ISSUES

Specific training of personnel was a key factor for success in implementing the UBD program. UBD tuition and crew understanding was achieved by a Shell Expro in-house training program.

The program incorporated rig site input into the operation from the conceptual stage, a three-day formal training program, and an offshore induction program.

Supervisory personnel visited land based UBD operations and participated in procedural reviews.

The program also provided for stepwise implementation of fully underbalanced drilling conditions. And a rig site 'hands on—no pressure' familiarization period gave the opportunity to test, develop, and improve communication between various services.

COMMUNICATION

The drill crew manning levels for the UBD campaign remained similar to those required for normal drilling operations, with the inclusion of an extra crane operator and safety officer during the rig-up phase. The maximum personnel-on-board (POB) restriction for the Santa Fe Britannia is 104. Total manning levels consistently exceeded 100 due to the requirement of more than 20 UBD-related contractors during the rig up phase.

Diligent planning coupled with good onshore to offshore communication ensured operations were managed with minimum disruption keeping as much of the rig up as possible as a non-critical path operation.

UBD operations changed the responsibilities of drilling personnel in the following ways.

The regular crew members were charged with the role of becoming the "rig" safety officers, responsible for ensuring that the housekeeping and third party working practices complied with the rig safety management system.

The Santa Fe driller was designated focal point for all UBD communications. He was expected to supervise additional personnel on the rig floor. There was an increased area of authority and knowledge for supervisory personnel extending from existing rig systems to pipe and valve systems routing through various UBD equipment packages.

Personnel were expected to deviate from standard well control mindset. And finally, personnel were required to operate under the guidance of the specific Shell Expro UBD supervisors.

RIG UP AND EQUIPMENT

The increased cost of the UBD operations required emphasis on careful planning, management, and use of craneage and deck space.

The sequence and delivery of major equipment packages were planned to make best use of transportation and more efficient placement on the rig.

Additional operations are typical of UBD requirements. It is necessary to rig up the required surface equipment, nipple up the UBD stack and associated snubbing well control equipment, pick up and rack back contingency drillstring components, then pick up drillpipe.

Stripping trials and a familiarization period are necessary to debug any equipment problems.

For the original UBD campaign, additional equipment totaled 140 tons and included numerous heavy lifts (UBD systems, steel pipe, nitrogen membrane units, and generators).

Spotting of the equipment was important, as there was not much room for error.

Footprints for every piece of equipment had been marked out in the planning phase.

Much of this equipment had little operation time in an offshore environment.

To counter this lack of experience and maximize the potential for UBD success, the following processes were implemented:

- All equipment was subjected to HAZOP and intensive design verification by the UBD team;

- A strict regime of component testing was put into place;

- All equipment measurements were double checked and footprints confirmed with prior offshore visits;

- Hazards of heavy loads were highlighted during the pre-job formal training;

- Pre-job safety meetings were conducted for every major step in the process and on every shift change;

- Area of testing was restricted to essential personnel only;

- Offshore Safety Officers provided 24-hour supervision to new personnel unfamiliar with the offshore environment.

WELL CONTROL

The surface well control equipment evolved from a basic jackup rig system (an annular preventer plus three rams) to a complex set up required for underbalanced snubbing and drilling operations.

The rig BOP presently consists of five rams and an annular preventer Two of the five rams are designed for operational use, leaving the remainder specifically for a well control event.

The additional operational rams are designed to provide cover for the high pressure riser and to enhance single barrier protection. Double isolation for the snubbing system from the wellbore can be achieved at all times.

At no time does the modification of the drilling system compromise the independence of the rig's well control equipment.

BOP PRESSURE TEST

It is good practice to attempt to time BOP pressure testing events when full hydrostatic overbalance convention is in place. However, this is not always possible. In the underbalanced mode, conventional practices cannot always be employed to test the BOP while the well is flowing. Inflow testing against fixed bore and variable bore rams can be considered as a means of testing.

BOP PANEL, ACCUMULATOR

The rig floor BOP control panel will be set up such that the rig's well control rams are controlled by conventional levers. The two additional rams are controlled from additional levers on the same panel.

SEPARATION EQUIPMENT

The surface separation equipment is continuously manned and protected from the well by hydraulically operated, air actuated emergency shut down (ESD) valves responding to high pressure and fluid levels, or manual activation.

Regulation of returns at surface is controlled by a choke manifold system (independent of the rig manifold), sited upstream of the separation package.

WELL CONTROL BASICS

While drilling in underbalanced mode, only a single well control barrier exists. This barrier exists within the gas envelope between the riser and the connection to the lowermost VBR on the rig BOP.

With the well live at all times, special techniques are required to control flow. To minimize risk, it is important that operations are scrutinized and the double barrier policy implemented whenever possible. For example, when out of the hole with the drillstring, two blind rams should be closed.

For the underbalanced operation, the conventional means of primary well control, an overbalanced hydrostatic barrier, is removed and thus procedures have to be implemented for this change.

The definition of "well control" is redefined as "flow control", meaning the maintenance of the inflow in a manageable window, defined by the surface control system operating limits.

WELL CONTROL STRATEGY

The strategy adopted to respond to a well control incident while underbalanced drilling, is to isolate the wellbore and return operations to a conventional well control situation. Well killing will be absolutely necessary when:

• Personnel safety or installations integrity is threatened or jeopardized;

• A persistent inability to maintain underbalanced drilling flow control exists;

• A leak in the BOP stack which cannot be isolated using the rig BOP is present.

HIGH PRESSURE RISER

The HP riser is defined as the weakest mechanical component in the BOP stack. For this reason the stress in the riser is permanently monitored and alarmed to flag any unforeseen rig movements.

BHA AND DRILL STRING

Underbalanced drilling with jointed pipe poses additional risks, increasing the number of potential leak paths compared to coiled tubing.

Drillpipe must be carefully selected, managed, and maintained to ensure the string is fit for purpose.Another vital component of the BHA for underbalanced drilling is the drillstring float. This one-way valve prevents flow up the drillpipe. Types with a mechanical lock-in for the float insert are preferable.

DRILL PIPE WEAR

Underbalanced conditions by their nature promote a wear rate higher than that experienced on conventionally drilled wells. Contingency planning and regular dimensional checking are required to avoid drill pipe failures. Particular attention should be paid to torque and drag modeling, and the premature onset of buckling, to help minimize these problems.

CONCLUSIONS

To date offshore underbalanced technology has been used to drill two low-head and six underbalanced wells safely from the Santa Fe Britannia. The success of the operation is due to the following factors:

A stepwise approach to UBD operations was used, allowing collective learning without the usual operational pressures that new technology brings. The first three wells were used to safely develop the technology and the subsequent wells used to mature it.

Discrete portions of the operation were addressed individually until confidence and competence levels were reached.

Team continuity allowed focus from conception to execution and continuous improvement, learned from good planning and cooperation between all contractors involved both onshore and offshore.

Avoidance of conflicts due to good supervisory management coupled with the appropriate education of the UBD process allowed individuals to understand their role and responsibility.

Maintaining offshore input throughout the project aided continued development of the UBD process.

Close scrutiny and qualification, including auditing, of all equipment and drillpipe components were critical to the project's success.

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