Assessment of BOP Stack Sequencing, Monitoring and Kick Detection Technology

Final Report 02 - BOP Monitoring and Acoustic Technology

January 23rd, 2014
Objective

• Investigate state-of-the-art industry practices for monitoring of subsea BOPs.
• BOP and BOP control system issues/failures and an investigation of the underlying root cause to assess what sort of condition monitoring is required/available.
• Assess existing acoustic technologies for subsea well control.
Outline

• Extensive review of BOP and BOP Control System Reliability
• Identify most frequent reliability issues
• Focus on control system reliability and testing issues
• Identify applicable BOP
• BOP Maintenance & Testing
• BOP Monitoring & Technology
• Alternate BOP Control Systems
• Reliability of Acoustic Systems
• Acoustic System Application History
Literature Review

• Comprehensive review of available literature such as API 53, API 59, API 16D, NTL 2008-G07, TAR 582, Sintef reports, West Engineering reports, Deepwater Horizon reports to capture specific requirements related to this project.

• A survey was developed and sent to Drilling Contractors, Service Companies, Technology Companies and Operators. The survey addressed the following areas:
  – BOP design
  – BOP sequencing
  – Shear ram technology
  – Shear alternatives
  – BOP reliability
  – BOP monitoring
  – Kick detection and well control
  – Kick detection technology
BOP System Reliability

- Control system failures are the most likely category of failure on BOP equipment.
- In all studies reviewed, the control system failures accounted for more than 45% of all failures. This is followed by annular preventer and ram preventer failure.
- Control system is the lifeline of the BOP and the conduit for diagnostics and monitoring of the BOP's health so the control system is the primary focus of this report.

Failure Distribution from Subsea BOP from Joint Industry Project
BOP and BOP Control System Reliability

- Literature review on BOP control system reliability was performed.
- Primary sources:
  - Study 1 - Phase I DW
  - Study 2 - Reliability of Subsea BOP Systems for Deepwater Application, Phase II DW
  - Study 3 – Reliability of Deepwater Subsea BOP Systems and Well Kicks
- MTTF has improved due to technology maturity.

Control System MTTF comparing three studies
BOP and BOP Control System Reliability

- No significant difference between the MTTF for MUX and conventional control systems. Significant increase in the downtime to repair MUX systems.
- MUX systems are relatively new and so the reliability data available on this type of system is not extensive.
- MUX systems have more subsea components and are more complex than conventional systems.
- In a conventional system, the hydraulic side leakages could cause leak of fluid into the sea whereas any leaks in MUX electrical systems can result in complete failure.
The majority of control system failures were due to malfunctioning of the different components on the control pods on the LMRP.

Failures were due to leakages in the control pods, Subsea Plate Mounted (SPM) valves, solenoids, malfunctions of the choke line fail safe valves on the stack connector regulator.

Loss of all functions on both pods was observed but these instances are in the minority compared to Loss of partial/complete function of one pod.

A significant number of the BOP failures occurred during BOP operation subsea.
BOP Maintenance & Testing

- Paper circular chart recorder (CCR) is normally used for documenting the testing of the BOP on rig surface
- Problems associated with the chart recorder are:
  - Hand written notes led to lot of data manipulation and mistakes
  - Hard to keep track and document the tests on all the different valves.
  - Most leaks happened in low pressure tests and the clarity of the pressures on the chart recorder was not clear in the low ranges.
BOP Testing System – Suretec

- SureTec is a data acquisition software specifically used for testing the BOP on the stump and subsea.
- Allows for remote BOP pressure testing which provides an independent means of witnessing a BOP pressure test from onshore.
- Around 25 rigs are presently using SureTec.
BOP Testing System – Greenlight

- Greenlight is a pressure test verification system utilized in pressure testing of wells, well systems and well components.
- System consistently approves or rejects pressure tests against predetermined test criteria, removes the subjective element, generates a detailed pressure test chart which can be annotated, e-mailed and filed.
- Detailed pressure chart provides auditable record and unambiguous proof of compliance.
Real Time Monitoring Systems – Rig Watcher

• Real time monitoring systems collect raw BOP data from pressure switches, solenoids, pressure transducers and flow meters to allow cycle based maintenance of the control systems sub components.
• Real time BOP monitoring which helps in proactive maintenance and early identification of problems. Allow for 24/7 monitoring of the BOP from onshore.
• Allow cycle maintenance by determining the useful life of the BOP components.
• Data such as pressure and flow versus time profile signature identifying potential equipment problems.
Real Time Monitoring Systems – NOV BOP Dashboard

• Major functions on the BOP can be monitored through this system.
• The levels of risk associated with each traffic light are defined by assigning three colors to provide the BOP health status.
• Communication tool for allowing communication between the operations team on BOP health issues. The event logger on the rig is the primary diagnostic tool.
• BP has been piloting the BOP dashboard system on Ensco DS-4 drill ship in Brazil with NOV and Ensco. BP's first installation in the GOM on the Ensco DS-3 drill ship.
Real Time Monitoring Systems - Drilling iBox

- GE’s Drilling iBox is a combination of hardware and software solution which is used to convert existing data from the event logger into reports, status updates, event sequence, cycle counts.
- Event sequence and cycle counts can be used as condition based and predictive maintenance tool.
- The iBox connects to the existing data logger on the rig and provides diagnostic and predictive condition monitoring reports.
- The iBox system can be retrofitted to all the GE BOP MUX control systems. BOP can be monitored in real time from an onshore facility to help with diagnostics and troubleshooting.
Real Time Monitoring Centers

- Multiple companies such as BP and Talisman Energy have started Real time Monitoring Centers which enable 24/7 monitoring of well parameters from onshore location.
- This capability is designed to enhance the safety of deep water operations. The data that is available to the personnel at the monitoring center allows for an extra pair of eyes to monitor well parameters.

![Real Time Monitoring Center Image]
Condition Monitoring

- Condition monitoring is continuous/periodic measurement and interpretation of data to indicate the condition of an equipment to determine the need for maintenance.
- Faulty BOP valve resulted in an inability to test the shear/blind ram which required the BOP to be pulled out of water which took 14 days round trip and cost $10.1 million downtime to a drilling contractor.
- BOP downtime loss for this drilling contractor was $80 million in 2011 and $60 million in 2012.
- If the drilling contractor had known the cycles the valve had undergone, the part could have been replaced before it failed.
Ram Position Monitoring

- GE’s Ramtel
- EFC Ram Sensor
- NOV Ram Position Indicator
- OBAR BOP Ram Position Monitoring
Alternate Control System – MODSYS

- Limitation of current control system.
- Modular Control system (MODSYS) is lightweight, easily configurable, ROV compatible system which is compatible to work with all BOPs.
- Standardized, segmented units are used that helps in easily configuring for specific jobs without affecting the basic equipment. Using the MODSYS lets an ROV equipped with tooling kit to descend with a replacement control system module and install it in four to eight hours.
- ATP’s Oil and Gas Subsea Isolation Device (SID) on the Titan platform in GOM and was in operation for more than 20 months in 4,000 ft of water.
- Acoustically controlled SID for two years on the Aban Offshore’s drill ship in 8,000 ft of water in Brazil.
Reliability of Acoustic Systems

- Reliability data available on older analog systems.
- Analog acoustic data for 1977-1998 shows no trend in Mean Time to Failure (MTTF) of analog acoustic control systems.
- From 602 acoustic tests, 4 failures were due to signal transmission (0.66%) or a signal transmission success of 99.34%.
- Comparing this to digital acoustic systems the Nautronix Nasbop system had an average signal transmission success of 99.3% based on short duration deployments.
- Consistent with the digital acoustic performance on the Shell ESG deployment where it was recommended to assume that 1 out of 100 attempts to transmit signals fails, i.e. 1%.
- Mean Time Between Failures (MTBF) was 164,000 to 39.4 x 10⁹ hrs for Sonardyne digital acoustic depending on the system configuration.
- Digital acoustic systems are becoming more reliable but more time in the water is still required.
- Acoustic systems have not been used to function the BOP during a well control event.
Acoustic System Application

- Environmental Safe guard
- Subsea Isolation Device
- Capping Stack
- Vessel of Opportunity
- ROV Retrievable Acoustic system
- Acoustics Replacing MUX System
- Macondo Operations
Summary

• Comprehensive review of literature was completed

• BOP Mfg, Operators, Service companies, Drilling Contractors, Technology companies and Universities were contacted

• Control system failures are the most likely category of failure on BOP equipment followed by annular preventer and ram preventer failure.

• BOP control system MTTF has improved significantly in recent years due to technology maturity.

• To improve the reliability of the BOPs when subsea, more rigorous BOP maintenance and testing requirements, as per API 53, shall be implemented.
Summary

• Test verification software such as Suretec and Greenlight would eliminate some of the inaccuracy and human error associated with traditional chart recorder techniques.

• Real time monitoring systems like Ashford Technology's Rigwatcher, NOV's BOP dashboard system and GE's drilling iBox system collect raw BOP data from pressure switches, solenoids, pressure transducers and flow meters to allow cycle based maintenance of the control systems sub components.

• Real Time Monitoring Centers (RTOC) would enable 24/7 monitoring of well parameters to enhance the safety of deepwater operations.

• Ram position monitoring is offered by many vendors and utilizes a broad range of technologies, including direct ram position monitoring, indirect flow meter calculation, tail rod monitoring using ROV etc.
Summary

- Condition Monitoring would eliminate the root cause of equipment failures and anticipate the needs of the equipment. Repairs can be planned before they turn into major failures which could lead to catastrophic results.

- Modularization of control systems offers quicker replacement of control system module.

- Digital acoustic systems are becoming more reliable but more time in the water is still required. Digital acoustic systems are also being considered for capping stacks, vessel of opportunity and to replace the MUX system.

- As drilling continues in deep and ultra-deep water, the time and expense to fix the control system failures will increase substantially. The industry has to innovate and embrace new technologies which are simpler, lighter, modular and highly reliable which can replace the traditional control system.
Reference

• Final Report 02 – BOP Monitoring and Acoustic Technology
Questions