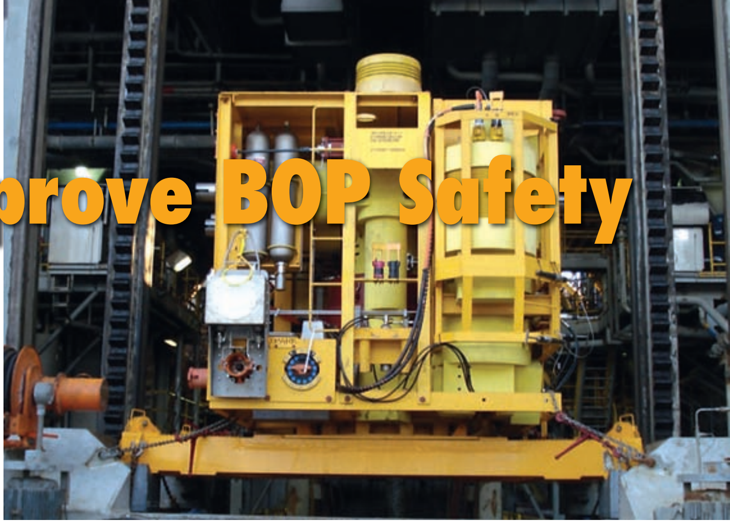
Class Works to Improve BOP Safety



Research efforts target BOP maintenance, inspection, and testing in deep water.

BY RANDY MONTGOMERY AND BRET MONTARULI

***FMC Technologies' 10K Enhanced Vertical Deepwater Subsea Trees (EVDT) holds the world record for the deepest subsea tree system at about 9,600 feet** (photo: FMC Technologies)*

The blowout preventer (BOP) is one of the most critical safety device in offshore drilling operations. The Macondo incident in the Gulf of Mexico (GoM) in 2010, during which tens of millions of barrels of oil were released into the ocean, was a stark reminder of how catastrophic the results of a BOP malfunction can be.

Located at the wellhead, the subsea BOP is made up of several independently operating shutoff valves that isolate the well in the event of an emergency. The BOP also has an emergency shutoff mechanism that allows the well to be completely shut in. In fact, a subsea BOP performs multiple roles – helping to prevent risk and working as an emergency response tool. It is crucial that the BOP work reliably because one or more failed components could affect the BOP's functions.

While BOP failures are rare, the dramatic consequences of failure have moved BOP safety research to the forefront for operators, drilling contractors, oil service and supply companies and class societies like ABS. Significant time, effort and resources are being invested to evaluate BOP systems and to develop practices that allow them to work more reliably.

Evaluating Reliability

In the course of research efforts that concluded in mid-2013, ABS, ABS Consulting, a number of operators, drilling contractors, and BOP equipment manufacturers joined forces to investigate BOPs and associated control systems operating in deep water. Several BOP configurations were evaluated, including:

- BOP with a five-ram configuration and single annular or a four-ram configuration with a dual annular.
- BOP with a five-ram configuration and dual annular or a six-ram configuration with a single annular.
- BOP with a six-ram configuration and dual annular.

For the purpose of the research effort, analysis targeted the surface and subsea control systems and the BOP stack. BOP stack components included annulars, blind shear ram, casing shear ram, pipe and test rams, choke and kill lines and valves, gas bleed valves, connectors, and stack-mounted accumulators. The surface system evaluation encompassed the hydraulic power unit, electrical power, multiplex (MUX) control line, rigid conduit and hotline, surface accumulators and control panels. The subsea control system included blue and yellow pods (which operate functions on the BOP stack in response to commands from the surface control), the lower marine riser package (LMRP) mounted accumulators, and emergency and secondary controls.

The functional scope of the study comprised failure mode, effect, and criticality analyses (FMECAs) and reliability, availability and maintainability (RAM) studies on a number of BOP functions. These studies examined how to safely close and seal the drillpipe and allow circulation on demand, how to close and seal an open hole and allow volumetric well control operations on demand, how to strip the drillstring using the annular BOP(s), and how to hang off the drill pipe on a ram BOP and control the wellbore.

Additional evaluations looked at controlled operation – shearing the drillpipe and sealing the wellbore – and emergency operations that entailed autoshearing the drillpipe and sealing the wellbore and emergency system disconnects, where the drillpipe would be sheared and the wellbore sealed. The team looked at issues surrounding disconnecting the LMRP from the BOP, how the well would be circulated after the drillpipe was disconnected, and how circulation across the BOP stack would remove trapped gas. The final component of this series of tests was BOP/LMRP connection at landing.

The primary objective of the research was to provide information related to BOP maintenance, inspection, and testing for units operating in deepwater in the GoM. As part of the research, the team compiled and analysed data and information related to BOP system failure events as well as maintenance, inspection, and testing (MIT) activities. This effort involved collecting failure event and maintenance task data from more than 20 rigs and analysing more than 400 failure events. Results included failure and maintenance event trends and estimation of BOP and subsystem mean time to failure values.

In addition to this work, FMECAs were performed on selected rigs. The FMECAs associated equipment-level failure modes to BOP functions, aligned key MIT activities to the equipment-level failure modes, and assessed the risk of equipment-level failure modes.

FMECA results indicate surface and subsea control system failures account for more than 60% of BOP system failures. The BOP stack accounts for the remaining failures. Further analysis of the failure events indicates that the following five major components account for

Research Yields Prolific Results

While the focus of this BOP research was to gather data and provide information for BOP maintenance, inspection, and testing specific to deepwater operations, the result was a number of additional reports on subjects, including:

- Estimating BOP performance in terms of mean time to failure and mean availability
- A review of planned and performed maintenance, inspection, and testing (MIT) tasks
- Aligning MIT tasks with potential BOP equipment failures
- Comparing MIT task requirements contained in regulations and industry standards/ recommended practices
- Surveying reliability and maintenance management systems related to BOP maintenance

approximately 75% of the BOP system failures:

- Blue and yellow pods.
- MUX control system.
- Pipe and test rams.
- Connectors.
- Choke and kill valves and lines.

Significant equipment-level failures occur in blind shear rams, casing shear rams, connectors, pods, choke and kill lines and valves, pipe rams, and hydraulic supply lines.

MIT activities used to detect and prevent BOP equipment failures included function tests, pressure tests, rebuilding/replacing equipment, and dimensional/ultrasonic testing. RAM studies based on a typical configuration for a BOP design were carried out with the goal of estimating the key reliability factor of merit, mean availability. Results indicate mean availability (while the BOP is latched on to a well) is as high as 99.9+%, depending on the BOP design and the assumed functions required to control the well. Results were used to predict the probability of a BOP being operational to control a well kick.

Research work included a review and comparison of BOP MIT tasks in two categories, those required by various regulation and industry standards/recommended practices and those contained in the MIT plans developed by drilling contractors. This effort included a survey of management systems and practices related to BOP maintenance activities. Results indicate API Standard 53 is the key document in defining the minimum MIT tasks for a BOP. The bulk of the drilling contractor MIT plans and BOP OEM installation, operation, and maintenance manuals include tasks that refer to API Standard 53 requirements. Many good practices are in place to help eliminate failure, including computerized maintenance management systems, overall maintenance management systems, preventive maintenance programs, written instructions, and training.

The Way Forward

This research evaluated field data to discover common BOP failures and identified the methods being applied to increase reliability. Additional research could target enhanced BOP safety and improved maintenance, inspection, and testing regimes.

Deepwater drilling operations are critical to meeting the growing demand for hydrocarbons, and the industry can only continue pushing the boundaries of what is possible if the technologies applied are safe and reliable.

For offshore operations to continue to take place in deepwater and harsh environments, there has to be confidence that the work of producing oil and gas can be carried out in a manner that promotes the security of life and property and preserves the natural environment. ■

Rule Improves BOP Inspections

Approximately a month after the Macondo incident in the Gulf of Mexico (GoM), Ken Salazar, then secretary of the US Department of the Interior, issued a report titled, "Increased Safety Measures for Energy Development on the Outer Continental Shelf." The report, issued through the Bureau of Safety and Environmental Enforcement (BSEE) recommended a number of changes for improving the safety of oil and gas exploration and development.

The Interim Drilling Safety Rule, which became effective on 14 October 2010, called for prescriptive requirements addressing subsea and surface blowout preventers, well casing and cementing, secondary intervention; unplanned disconnects, recordkeeping, well completion, and well plugging.

The rule included:

- New casing installation requirements.
- New cementing requirements (incorporating API, RP 65, Part 2, Isolating Potential Flow Zones During Well Construction).
- Required independent, third-party verification of blind-shear ram capability.
- Required independent, third-party verification of subsea BOP stack compatibility.
- New casing and cementing integrity test requirements.
- New requirements for subsea secondary BOP intervention.
- Required functional testing for subsea secondary BOP intervention.
- Required documentation for BOP inspections and maintenance.
- Registered Professional Engineer to certify casing and cementing requirements.
- New requirements for specific well control training to include deepwater operations.

On 15 August 2012, BSEE announced the Final Drilling Safety Rule had been released. The opportunity for public comment was included in the release of the Interim Drilling Safety Rule, and the Final Rule includes refinements based on consideration of the input gathered.

In a press release, BSEE explained that the Final Drilling Safety Rule establishes new standards for casing and cementing, including integrity testing requirements; third-party certification and verification requirements; BOP capability, testing, and documentation obligations; and standards for specific well control training, to include deepwater operations. The Final Rule also addresses requirements for compliance with documents incorporated by reference; enhancing the description and classification of well-control barriers; defining testing requirements for cement; clarifying requirements for the installation of dual mechanical barriers; and extending requirements for BOPs and well-control fluids to well-completions, workovers, and decommissioning operations.

A significant change to the inspection and certification process was the requirement of third-party verification. The independent third party must be a technical classification society; an American Petroleum Institute (API) licensed manufacturing, inspection, and/or certification firm; or a licensed professional engineering firm capable of providing the required verifications. The third party's role is to verify that a subsea BOP stack is designed for the specific equipment used on the rig, that it is compatible with the specific well location, well design and well execution plan, and that it was not damaged or compromised during prior service.

As a technical classification society, ABS provides certification of offshore drilling systems based on its *Guide for the Certification of Drilling Systems*, which incorporates the latest industry and international standards.

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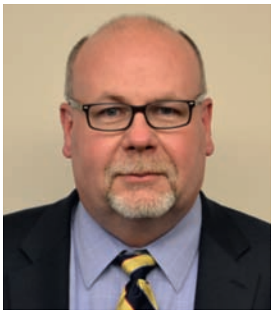

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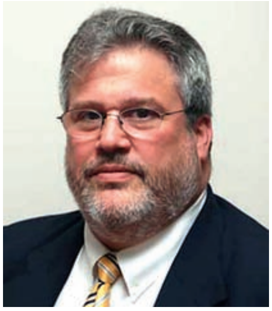

Based in Houston, Bret Montaruli is the Vice President of Offshore Technology for the American Bureau of Shipping. His responsibilities include guiding R&D activities and ABS Rule development in the Offshore, Subsea, and Renewable Energy sectors. During Mr Montaruli's 32-year career with ABS, he has filled positions including, Vice President of Engineering for the Americas Division and Manager of Offshore Engineering.