The Developing Design of the Blowout Preventer in Deep Water

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National Oilwell Varco
Possible New Requirements

• ROV Viewable Ram Position Indicator
• Secondary Control Systems & Associated Accumulator Volume.
• Shearing Capacity
• Black Box
§ 250.442 What are the requirements for a subsea BOP system?

1. Have at least four remote-controlled, hydraulically operated BOPs.
2. Have an operable dual-pod control system to ensure proper and independent operation of the BOP system.
3. Have an accumulator system to provide fast closure of the BOP components and to operate all critical functions in case of a loss of the power fluid connection to the surface.
4. Have a subsea BOP stack equipped with remotely operated vehicle (ROV) intervention capability.
5. Maintain an ROV and have a trained ROV crew on each floating drilling rig on a continuous basis. The crew must examine all ROV related well control equipment (both surface and subsea) to ensure that it is properly maintained and capable of shutting in the well during emergency operations.
6. Provide autoshear and deadman systems for dynamically positioned rigs.
7. Have operational or physical barrier(s) on BOP control panels to prevent accidental disconnect functions.
8. Clearly label all control panels for the subsea BOP system.
9. Develop and use a management system for operating the BOP system, including the prevention of accidental or unplanned disconnects of the system.
10. Establish minimum requirements for personnel authorized to operate critical BOP equipment.
11. Before removing the marine riser, displace the fluid in the riser with seawater.
12. Install the BOP stack in a glory hole when in ice-scour area.
drilling activities, most BOPs used in drilling on the OCS are of similar design and are produced by a limited number of manufacturers. Furthermore, the BOPs for the relief wells drilled to intercept the Macondo well encountered unexpected performance problems, initially failing to pass new testing procedures developed in response to the Safety Measures Report, including failure of the deadman and autoshare functions. These multiple failures raise red flags as to the reliability of BOPs to adequately safeguard the lives of workers and protect the environment from oil spills in response to a large blowout. They also suggest the need to review regulations pertaining to well casing and design, the other area of likely failure in the Deepwater Horizon event.

(d) Documentation and Reporting - The regulations issued under section 7(a) shall require--

1. Ongoing submission to the appropriate Federal official of documentation of blowout preventer maintenance and repair within 24 hours of such maintenance and repair;

2. Prompt and ongoing real-time transmission of the electronic log from a blowout preventer control system to a secure location where it shall be available for inspection by the appropriate Federal official;

3. Maintenance of up-to-date design specifications of any blowout preventer in service;

4. Submission to the appropriate Federal official of any changes to the design specifications of a blowout preventer in service within 24 hours of such change; and

5. Prompt reporting to the appropriate Federal official of a failure of any blowout preventer or any component of a blowout preventer when used during a well control event.
Issues to consider when upgrading to Meet new GOM requirement

Shear Rams – Capable of shearing all pipe across the BOP
   Do they have the capacity?
   With MASP?
Autoshear and Deadman System – Required
   Not required in GOM
Acoustic Systems – Not Required in GOM
Required additional accumulator volume. – Weight, Space
   separate Skid and flying lead
Contamination, flushing
Additional Shear were originally recommended
  • Blind/Casing/Blind to address the large diameter tubulars and tool joints across the shear ram
  • Blind Rams “adequately spaced”

  • Compliance would take to long for it to be included in the IFR
  • BOEMRE advises that this requirement is coming as well as casing shears through the NTL process.

§ 250.416(e), Independent third party verification that the blind-shear rams installed are capable of shearing any drill pipe in the hole.
Effects Of Charpy S-135 Pipe

Effects From Charpy – S135

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<th>Pipe</th>
<th>ULT</th>
<th>Yield</th>
<th>% El</th>
<th>Red Area</th>
<th>Charpy</th>
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Effects Of Charpy S-135 Pipe

CHARRY Does’t Effect Puncture!!!

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<th>Pipe</th>
<th>ULT</th>
<th>Yield</th>
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What is a Shear SYSTEM?

- Accumulators
- Shear BOP (Operator)
- Shear Rams
SHEAR OPERATOR

Purpose = FORCE
Lots of it!
Shear Force – Lots of it!

\[ A_{wb} = 28 \text{ in}^2 \]
\[ P = 8025 \text{ psi} \]
\[ \text{Depth} = 10,000 \text{ ft} \]
\[ \text{Mud Wt.} = 15 \text{ ppg} \]

\[ F_{wb} = 227,000 \text{ lbs} \]

\[ P = 5000 \text{ psi} \]
\[ A_{op} = 380 \text{ in}^2 \]

\[ F_{op} = 1,900,000 \text{ lbs} \]

\[ F_{net} = 1,673,000 \text{ lbs} \]
Closing Ratio

Closing Ratio (CR) = \(\frac{A_{op}}{A_{wb}}\)

CR = \(\frac{380 \text{ in}^2}{28 \text{ in}^2} = 13.4\)

Operator Pressure Required to Overcome Well Bore

\(P_{op} = \frac{P_{wb}}{CR}\)

\(P_{op} = \frac{8025 \text{ psi}}{13.4} = 598 \text{ psi}\)
<table>
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<th>Operator Type</th>
<th>Shear Type</th>
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<th>Weight</th>
<th>Grade</th>
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Centralizing
Centralizing
Centralizing
Centralizing
Centralizing
Centralizing
Subsea Accumulators

15 Gallon Bladder Bottles

= 1/2 Gal Usable Volume Subsea
**BASIC SYSTEM**

- **Water depth** – Water Depth pressure is ADDITIVE to Hyd system pressure because return vents to sea.

- **Temperature** - Cooler temperature of seawater makes the gas denser, thus further reducing precharge pressure.

- **Adiabatic Discharge** – Rapid Expansion of a gas (N2) causes the gas to get very COLD, making it denser, reducing it’s pressure.
DEPTH COMPENSATED BOTTLE

Hydraulics Boosted

\[
\text{SW} = 5350 \text{ psi} \\
+ \underline{\text{N2}} = 5000 \text{ psi} \\
\text{Total} = 10350 \text{ psi}
\]

Sea Water

12000 ft = 5350 psi

N2 Pressures

\[
\text{Pmax} = 4000 \text{ psi} \\
\text{Pmin} = 2400 \text{ psi}
\]
Extra N2 bottle added to ensure complete stroke of Piston.
15 Gallon Bladder

Depth Compensated

98

7
ROV Intervention

ROV intervention did not function as expected.

Flow capacity of ROV stabs and ROV installed pumps were found to be inadequate. Confirmed by field tests.

High flow stabs being deployed. ROV companies are upgrading their systems.

BOEMRE mandates testing of ROV systems prior to deploying BOP stack.

No standard stabs. Compatibility between ROV and Stack must be verified.
The ram position indicator allows the visual and positive indication that the rams are: open, closed, or closed and locked.

Compatible with Shear, pipe or variable bore rams

Prototype tested
Beta Testing required
Timely Transmittal of Data

A survivable data storage device has been developed and is in Beta testing.

Capable of integration to a transmission vehicle to shore in real time.

There is a tremendous amount of information to be transmitted.
• **Getting Data to Shore**
  24/7 monitoring systems
  eHawk, Rig MS and Optimum

• **Realtime Monitoring to include the BOP Controls and Systems**

**Information that can be Provided:**
- Pressure Data
- Temperature Data
- Ram operation cycles (time stamp, odometer, closing pressure)
- Hook Load Logs
- Mud Pit Logs
- Tensioner Logs
- Maintenance records
- Drawings
- Heat Treat Records
Automated well control may not be ready:

The automation is only as good as the programming
Iterative – Computers run through every possibility every time- there is no such thing as close.
Heuristic – A human trait of relying on similar situations

The computer system may be considered an early warning system.
If variables exceed prescribed limits warnings are issued.
If variable exceed dangerous limits then the system is shut in.

This can save precious minutes to shut-in the well.
Better to be safe, assess the warnings and before re-starting drilling operations

Barriers to Automation
Risk of being wrong can cost Lives and Money
Not identifying a series of events as being dangerous has serious legal implications

Implement in Stages