U.S. Dept. of the Interior Forum on Next-Generation BOP and Control Systems Technology, Management, and Regulations

New Design Requirements for BOP Assurance

Based on findings of:

National Academy of Engineering Committee for the Analysis of Causes of the Deepwater Horizon Explosion, Fire, and Oil Spill to Identify Measures to Prevent Similar Accidents in the Future

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New design requirements should AT LEAST eliminate known failures

- Available information on the capabilities and performance of the BOP system at the Macondo well points to a number of deficiencies that are indicative of deficiencies in the design process.
- The BOP system at the Macondo well was neither designed nor tested for the dynamic conditions that most likely existed at the time that attempts were made to recapture well control.
- The flaws in the BSR design, which would not shear and seal a modest 5½-inch-diameter drill string (well below its rating) in compression, significantly contributed to this national disaster.
- BOP systems should be redesigned to provide robust and reliable cutting, sealing, and separation capabilities under the "most demanding condition to be expected."

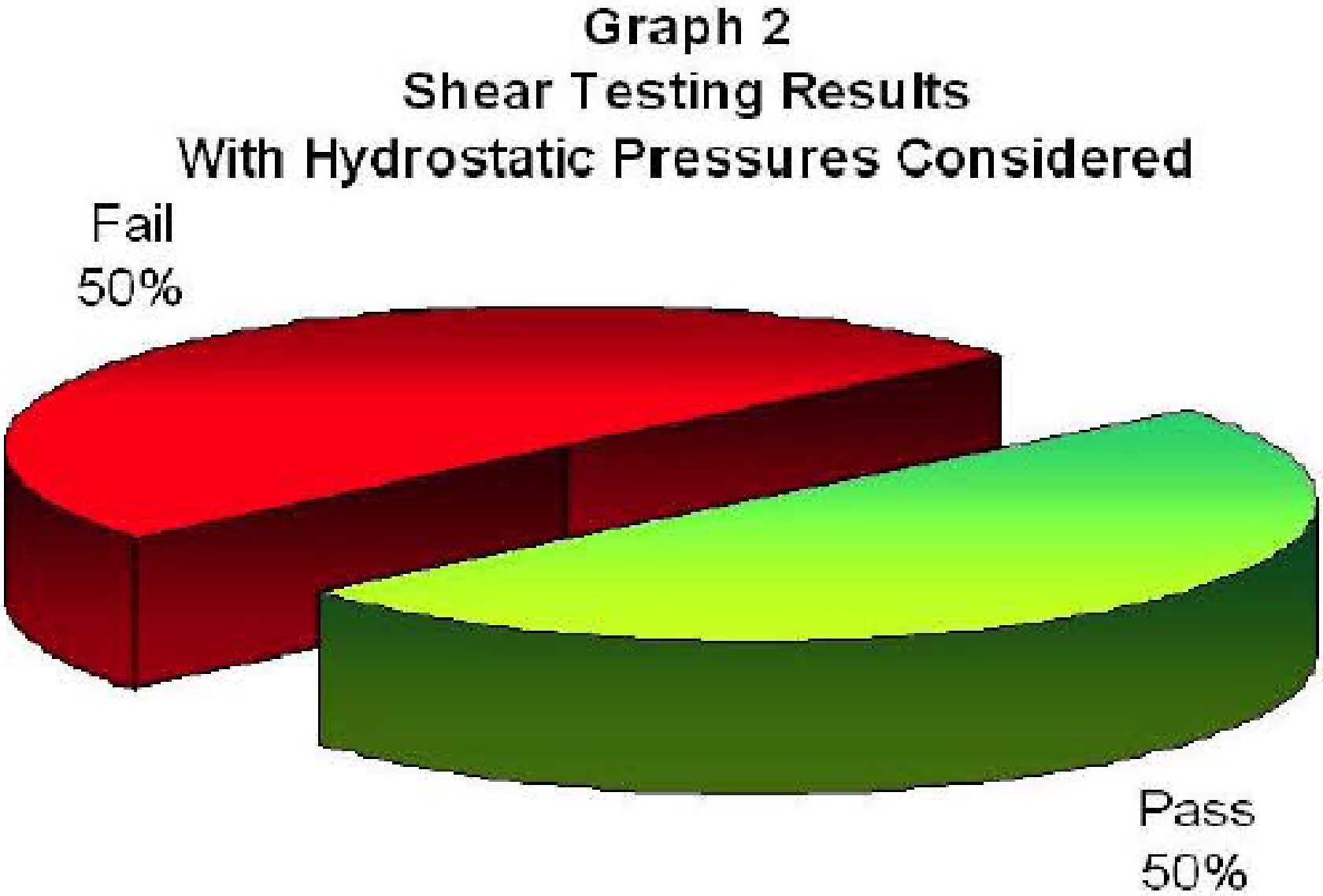
Philosophy of Design Requirements

- The NAE committee firmly believes that new design requirement should be performance based and not prescriptive.
  - Prescriptive regulations inherently eliminate innovation or application of new technologies
  - Prescriptive regulations often lag the drilling technology being employed by industry.
  - Drilling deeper and under more demanding drilling conditions is inevitable, and not be properly addressed by prescriptive regulations
- Design requirements must address failures in real world experience

Conformance with new design regulations must be based on TESTING reflective of worst case dynamic conditions

- "This study was designed to answer the question 'Can a given rig's BOP shear the pipe to be used in a given drilling program at the most demanding condition to be expected?' This can only be demonstrated conclusively by testing."-West Engineering to MMS, 2002
- "This limited data set from the latest generation of drilling rigs paints a grim picture of the probability of success when utilizing this final tool in securing a well after a well control event." – West Engineering to MMS, 2002
- Recent studies of BOP "reliability" have been flawed because of the inclusion of operational experience under benign "non-emergency" conditions.
- Such results do not accurately reflect emergency performance, but dominate "hours of use" data.

West Engineering 2002-4



The West Engineering tests:

- Were static. No dynamics considered
- Were conducted with drill strings centered in the BSR, and in tension
- Were conducted under ambient conditions “corrected” for pressure.
- Yet a 50% failure rate under essentially ideal test conditions did not spur redesign.
- Under new design regulations test failure should prohibit BOP use.

Update to BOEM on JIP Study on Reliability of Subsea Blowout Preventers

September 13, 2010
Lafayette, La

Frank Gallander,
Chair, API RP-53 C

RESULTS OF SUBSEA BOP RELIABILITY

Equipment Probability of Success: 99%+

Component	p_s, (%) based on test frequency	
	14 days	35 days
Annulars	99.62	99.06
Rams		
Fixed	100	100
VBR	99.78	99.46
BSR	99.82	99.55
Casing shear	100	100
Choke and kill valves	99.99	99.97
Connectors	99.93	99.82

New regulations must address the design flaws in DWH BOP

- **"WEST is unaware of any regulatory requirements that state the obvious: that the BOP must be capable of shearing pipe planned for use in the current drilling program." - West to MMS 2002**
- **The entire BOP system design is characterized by a long identified, conspicuous lack of redundancy, e.g.:**
    - **One BSR.**
    - **One shuttle valve used by both control pods.**
    - **Each MUX cable should monitor all BOP systems independently.**
- **There appears to have been no design consideration given to BSR performance on pipe in compression.**
- **The BSR is not designed to shear all types and sizes of pipe that might be present in the BOP.**

New design regulations have to account for real emergency chaos

- A perfectly designed BOP can be useless if the operators do not know or understand how and when to use it.
- A rig crew in any high stress emergency situation cannot be expected to execute a complex sequence of actions.
- Instrumentation and expert system decision aids should be used to provide timely warning of loss of well control. If the warning is inhibited or not addressed in an appropriate time interval, autonomous operation of the safety systems on the rig should occur.

Transocean BSR procedure

2.1 Recommended Practice

1. Space-out to ensure that there is no tool joint opposite the shear rams.
2. Close the hang-off rams and hang-off the string.
3. Ensure that the pipe above the hang-off rams remains in tension.
4. Close the shear ram at maximum accumulator pressure.
5. Monitor the well

The DWH crew did not know the conditions in its BOP

- Lack of status monitoring, e.g.:
  - Control Pod Battery condition.
  - Condition of the solenoid valves.
  - Flow velocity inside the BOPs.
  - Ram position.
  - Pipe and tool joint position inside the BOPs.
- The faults in the BOP system were not detected and did not cause drilling operations to cease.
- The current shear rams probably will not seal if the pipe is in compression.

BOPs have historically failed to seal drill string or tube in compression

Attachment 5

MMS

U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region

SAFETY ALERT

Safety Alert No. 187
April 3, 2000

Contact: Joe Gordon
504-736-2923

Coiled Tubing Incidents

Two recent coiled tubing operations in the Gulf of Mexico experienced similar operational problems that culminated in uncontrolled well flow events. In both situations, coil tubing was being snubbed into the wellbores when the coiled tubing strings encountered unknown obstructions, causing the coiled tubing to stop abruptly. The abrupt stop and resulting compression of the coiled tubing caused the tubing to part between the injector head and the stripper assembly. In both situations, the blowout preventer (BOP) was activated, but BOP intervention failed. The tubing was successfully sheared in both cases but could not be pulled

"In both situations, the blowout preventer (BOP) was activated, but BOP intervention failed."

Recommendations

1. The BOP design must be robust and highly reliable under all foreseeable normal and extreme operating conditions.
2. The design of the blind shear ram (BSR) must be vastly improved to shear and seal all conceivable combinations of pipe under all possible conditions of load from the pipe and from the well, with or without human intervention. This must be a “fail safe” system.
3. This performance must be demonstrated and certified on a regular basis by test or other means that offers the public the assurance to which it is entitled.

Recommendations cont'd

4. The instrumentation on the BOP system must be vastly improved so that the functionality and condition of the BOP can be monitored on a continuous basis.
5. An unambiguous procedure, supported with automation, must be created for use of the BOPs. An expert system should be devised to provide a warning ideally followed by an automatic BOP activation after a given time period has expired.
6. A faulted BOP system should cause drilling operations to cease.

Lesson

The several different systems on the BOP that failed to perform their intended function on 20-21 April made the difference between what could've been merely a kick, or at worst a tragic industrial accident with injuries and fatalities, but instead resulted in the loss of a MODU and an unparalleled national disaster.

"Those who cannot remember the past are condemned to repeat it“

- Jorge Agustín Nicolás Ruiz de Santayana y Borrás (1963-1952)

Questions?