Top Kill Carolinian Report

Deepwater Horizon Review

Monday May 31, 2010
Agenda

- Top Kill
- Diagnostics & Analysis
- Containment
- LMRP Cap Containment
- LMRP Cap/Near Term BOP Containment
- Long Term BOP Containment
- Relief Wells
Summary of Execution

- Top Kill Statistics:
  - 3 separate attempts over 3 days.
  - Pumped total 30,000 barrels of heavy mud at rates up to 80 bpm, 1,100 psi surface pressure, 6,000 psi wellhead.
  - Fired 17 different bridging material shots (varying sized balls, cubes and misc objects).
  - 29 vessels in the area, including 10 ROVs.

Top Kill #1 May 26th
Pumped 13,100 bbls, 16.4 ppg, 53 bpm

Top Kill #2 May 27th
Pumped 6,800 bbls, 16.4 ppg, 25 bpm with 15 shots of bridging materials

Top Kill #3 May 28th
Pumped 9,800 bbls, 16.4 ppg, >70 bpm, with 2 shots of bridging materials
Top Kill Pump Actual Performance

Key Messages:
- The operation was limited by available rate, not pressure.
- Back pressure required to kill well not generated.
- Pressures flat lined once a ca. 700 psi pressure drop was reached.

Mudline Pressure

8000 psi

7600 psi

700 psi

6300 psi max

BP

Planned

Actual

Back to full Reservoir Pressure

Disk 3

Disk 2

Disk 1

Single Phase Flow

Two Phase Flow

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**Scenarios to Explain Top Kill Results:**

**Defining Observations**

1. Immediately after pumping ceased, hydrocarbons were seen venting at the kink (plume color at the kinks quickly reverted to brown as previously observed for oil/gas).

2. During the kills, always appeared to have gas entrained at the vents in the kink (similar energy/velocity as oil/gas only, but with a grey color due to mud).

3. During Kills, pressures reduced for a while by a maximum of ca.700 psi (for a fixed rate) independent of the rate though “Flat-Lined”.

4. Pressure below BOP recovered back to near starting pressure very rapidly as pumping ceased.

5. Pressure drops across rams in BOP have remained, although they have reduced somewhat.

**Implications**

- Hydrocarbon (HC) not displaced very far from wellhead

- HC must have alternate path to mud going in, probably via drill pipe.

- Indicates level is controlling the pressure reduction in well. Coincident w/ rupture disc height.

- HC not displaced/limited mud column built in main flow path.

- Drill pipe (including 3.1/2”) is still present. Limited flow path by rams causing minor erosion.
Rupture and Burst Disk

- **Outward rupture of a burst disk**
  - No likely scenario

- **Inward rupture of a collapse disk**
  - Need 1,600 psi external pressure differential
  - Reasonable high external pressure is due to 11.1 ppg mud, 3,490 psi
  - Therefore, need internal pressure less than 3,490 - 1,600 = 1,890 psi
    - Gas (.15 psi/ft) from surface = 907 psi
    - Oil (.25 psi/ft) from surface = 1,512 psi

- **Conclusion** – An event-related rupture of a collapse disk can be conjectured.
Conclusions & Path Forward

There is little chance of success repeating the top kill. While options might be available to change the method, these are unlikely to work and carry additional risk.

If there is a path open to formation then containment is the preferred option.

Shutting the well in (via BOP on BOP) is no longer a viable option.

Need to maintain BOP pressure below 4,221 psi

Relief wells are most likely solution to kill the well completely.
Containment

Objectives
- Systematically Minimize Pollution
- Maintain Base BOP Pressure < 4,221 psi
- Minimize Hurricane Affects

Approach
- LMRP Gap Containment
- LMRP Gap Containment/Near Term BOP Containment
- Long Term BOP Containment
- Relief Wells
LMRP Cap Containment

- **Risks**
  - Hydrate Formation
  - Cap “Chatter”
  - Visibility
  - Exceeding Enterprise Capacity
  - Hurricane
  - SIMOPS

- **Mitigations**
  - Methanol Injection
  - “Bypass” Flow Control
  - Subsea Dispersant

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LMRP Cap/Near Term BOP Containment
LMRP Cap/Near Term BOP Containment

Risks

- LMRP Cap
  - Hydrate Formation
  - Cap "Chatter"
- Near Term BOP Containment
  - Subsea System Integrity
  - Operability
  - Flow Assurance

- Both
  - SIMOPS
  - Hurricanes

Mitigations

- Methanol Injection
- "Bypass" Flow Control
- Balance Production Between Enterprise and Q4000
- Constant Subsea Monitoring
- Subsea Dispersant
Long Term BOP Containment

- Flare
- ROV/Ops Support Vessel
- Containment Vessel
- Storage Tanker
- Horizon LMRP
- Horizon BOP
- Hydrate Inhibitor
- Subsea Dispersant Option
- Free Standing Riser
- PSV 1
  - Hurricane Choke Vent
- PSV 2
Long Term BOP Containment - Schedule

MC 252 - Containment and Disposal Project
May 30, 2010

Activity
- Horizon BOP Tie-in
- Fabricate/Install
- Fabrication/Test Installation
- Riser/Install
- Flexible Jumper/Install
- Containment Vessel/Loch Ronnach
- Mobilize to Field
- Storage Vessel/Field
- Hook-up/Commission
- Start of Containment

June
- 27
- 20
- 13
- 6
- 30

May
- 30
Long Term BOP Containment
Toisa Pisces
Long Term BOP Containment
Subsea Manifold

- Subsea Manifold - Cameron
  - 10ksi rated
  - 35 tonnes
  - \( \sim 36' \times 24' \times 12' \) H

Structure / Frame

Valve Package
LMRP Cap/Near Term BOP Containment

**Risks**
- Schedule Delivery of multiple components
- BOP Connection with Overshot – installation engineering
- SIMOPS – installation activities and hand-off from Enterprise
- Hurricanes

**Mitigations**
- Dedicated project team
- Expediting multiple critical paths
- Onshore testing (sealing system)
- Contingency option (Flanged connection)
- Fully integrated with IMT planning and execution
- Subsea Dispersant