Report Outline

1. Background

Deepwater Horizon – 5th generation
Used for drilling exploration wells
Crew was recognized for high performance in personal safety

Macondo was an Infrastructure Led well (ILX)
Had a fair idea there were commercial quantities available
Plan to temporarily suspend well, later tie-in to Pompano

Spudded with Marianas, which was damaged in Hurricane Ida

2. Decisions

2. A. Soft Formation (Choice of Bore Size, Drilling Fluid, Casing, Centralizers,)

Issues encountered in well bore
- Weaker well than anticipated
- Had to commit two more casing strings

2. B. Bore Size Options
TD: 18,360'
8-1/2" bit; used a 9-7/8" side arm reamer (created elliptical bore to reduce Equivalent Circulation Density (ECD))
Soft formation, narrow margins; better for reducing ECD if bore is wider
Miocene, friable; easy to drill, formation not as hard as in the Rockies

2. C. Drilling Fluid Options
Drilling fluid was chemically inert

Tools were used to evaluate well: resistivity, gamma ray, …
Determined hydrocarbons available

Pressure:
13.1 12.6
14.1 formation; 14.2 mud weight

If used less weight, would flow
If used more weight, cause losses

2. D. Casing Options
Had to make a decision regarding: Long String vs. Liner options
Risk Assessment:
Liner with cement had lower ECD than Long String

EXHIBIT # 32
WIT:

Long String: Could have cemented

Liner risk: Risk of *trapped annulus*, but *less ECD* required
Long String risk: Less risk of *trapping annulus*, but *higher ECD* reqd.

2. E. Centralizer Options
Centralizers: intended to 1) reduce channelization, and 2) mitigate effects of the cement losing hydrostatics when phase shifts from liquid to solid

Casing bought from:
9-5/8" from BP
7" from Nexus, who provided only 6 centralizers

Halliburton specified 21 centralizers; BP ordered 15 more

Atlantis centralizers failed – integrity concerns
Thunderhorse centralizers sent – were available
Wells Team Ldr didn't know, so decided to go with 6
Risk consideration: Centralizers can get stuck in BOP or acute angle below

2. F. Cement Options
Subsequent report from geologists – HC zone above cement

Sophisticated cement slurry, three volumes – cap, nitrified, tail

Used base oil 10.6, to displace 14.6 mud (transition will not be smooth)

Defoamer blended
More difficult
More surfactant needed
Riskier design

Tried to inject at high end of N2 capacity (extreme end)
Question regarding slurry stability

3. Chronology of Events

3. A. Float Collar
Set float collar at bottom of casing; run in slowly to minimize surge

First anomaly – 9 attempts to convert; (blockage may have been at float collar or shoe?)
Checked with Weatherford for guidance to continue, said acceptable to increase pressure
May not have set sleeves

3. B. Cement Job
Cement job went as expected

No significant losses (some, 6 – 9 bbls.)
Returns suggest no kick

Displaced cement with rubber plug

3. C. Positive Pressure Test (to test casing and plug integrity)
Set seal assembly, pressurized from above
Positive test (tests rubber plug, not cement) – successful

3. D. Negative Test (to test integrity of well under sea water hydrostatic pressure)
Performed Negative test (had not set locking device yet)
Negative test simulates sea water hydrostatic on well in preparation for suspending
DP stinger down to 8367'
Spacer to displace synthetic oil based mud 14.1
Spacer is viscous
Empty pits to recover and transfer to boat
Guidance to pump X strokes of pill, Y strokes of sea water to result in pill 1000' above stack
May have misinterpreted; they pumped X total strokes; resulted in pill across BOP stack
Shut in Annular
Displace Choke, Kill to seawater
Shift handover was occurring (Bob going off for short change, Don coming on for short-change)
Started to monitor DP press
Don said must accomplish on Kill line per MMS
May have bled viscous into Kill line
Press on DP was 1400 psi, Kill line was 0 psi (though there was a U-tube connection)
Bled off larger amount than should have expected (15 to 23 bbls, vice ~ 2 bbls.). Question whether they were monitoring
Test took 3 hrs, vice 45 min.
Kill line: 0 psi – may have been blocked
DP: 1400 psi – explained away with "bladder effect" (Don had reservations about this explanation; was on his 4th trip, heard crew was good; eventually went along with the group explanation; Bob was a replacement for Ronnie)

3. E. Beginning of Influx
Well started to kick

3. F. Sheen Test (to determine if returns were oil-free, to allow dumping overboard)
Sheen test – good results
Began to dump overboard; flow sensors downstream, therefore can't read flow from well

3. G. Crew Response (after Abnormal Indications first recognized)
2131 – abnormal pressure begins to build
Crew tried to shut in well
Mud through rig floor

Diverter lines (may have failed)
Gas heard escaping
Small explosion (possible overspeed of motor heard)
Catastrophic explosion

One light on bridge panel: "Lower Annular"
Attempt to EDS – didn't get desired result
Shut diverter, lined up to Mud Gas Sep (100 psi constrained system)
May have been a conservative approach to avoid dumping to sea, or following procedures

Deadman – No evidence that activated

Autoshear – Not conclusive if motion occurred

4. <u>Critical Factor 1</u> – Cement Barriers, Casing Mechanical

Cement failed to isolate
Hydrocarbons into casing (strong possibility through the bottom)
Though can't determine, there were factors that introduce weakness and potential risk

Quality of reviews, engineering checks, to see if could have been captured
Unforgiving well
Bought expensive cement
Remember, "Cement failure does not equal blowout"

Possible recommendation – More rigorous reviews

5. <u>Critical Factor 2</u> – Integrity Test

Narrow pore press / fracture gradient
Integrity test is the last chance to determine if we got it right

Rig crew didn't come to correct conclusion; looked at information, drew wrong conclusion

Test not specifically req'd by MMS; but once we specify in our plan, becomes mandatory

Still had control of well; had chance to remediate
1. If detailed procedure, with pass/fail criteria
2. If different instincts, …

6. <u>Critical Factor 2</u> – Well bore monitoring

As you circulate sea water, less pressure, encourage more flow

Normally monitored by Driller and support staff

Well flowing for one hour, not identified
Critical, fundamental drilling process

Because they concluded they had integrity, because they had other things going on, because they formed an incorrect mental model…
It appears they didn't identify flow; not in realm of possibility
Transferring between ~10 active pits out of ~20 pits (not transferring directly to boat)

7. Critical Factor 3 – Shut in Response

2131 – Crew realized something not right

[Before these last 18 minutes, crew was running out of margin; from this time forward, they had to respond flawlessly, and even then they still would have had gas release]

Next 18 minutes - initial response from a Driller that appeared to have not known was in a serious well control incident
1. Response was slow [trying to get approval?]
2. Equipment selected indicated minor response actions (Mud Gas Separator, which directed gas to the rig
3. Equipment took a long time to conduct operation [still analyzing?]

If overboard, might have delayed rig explosion
If concerned with dumping overboard, may indicate had minor concern
Also, could be following prescriptive training (procedure step says use Mud Gas Separator, then Diverter)

8. Critical Factor 4 – Ignition Source

9. Critical Factor 3 – Shut in Response

Difficult to determine
Plausible the equipment was damaged post-explosion, so EDS couldn't work
Deadman, Autoshear – By this time, a lot has gone wrong

10. Conclusions

Cost cutting? Inappropriate to say cost is not a consideration
Number of choices made – none were cost-cutting choices

As we went through decisions, was the quality of risk decision on the side of conservatism?

Believed we could do it safely, but lost track of aggregate risk

All the following are expensive options:

Casing
Connections
Mud
Cement
Three company Men (vice one)
Boats on the side

11. Recommendations

There were opportunities that could have reduced the likelihood
Ensure we don't miss the those opportunities in the future

1. Design of equipment
2. Checks and balances in place
3. Always monitor
4. Shut in response commensurate with magnitude
5. Emergency System function under duress