

**Notes on FRTG Conference Call, July 30, 2010****12:00-12:15 Tom Hunter Intro/Intent/Chronology**

281 366-5794 to get package

Basis and framework for finalizing flow estimates. How to arrive at a new position on flow.

Collection: into the ships  
Flow - based on oil

Slide 4 - chronology (summary of things that affect flow).

Consensus on new estimate of flow.

**12:15-12:45 Bill Lehr Flow Visualization Before TopHat-4**

Post-riser cut was most accurate (slide 12)

Described method for spatially varying velocity field. Actually looking at turbulent structures in motion.

Slide 16: Can't integrate across cross section to get flow rate. Only can see the skin of the jet. Most important source of uncertainty.

Used literature references to get ratio of outer speed to average flow rate (1.6 to 2.5). Need to do more work to refine this. Used black smoker results to confirm.

Uncertainties (slide 18). Ratio mentioned above, temporal fluctuations, GOR and its variation in time, ROV velocity.

Slide 19 results - prior to top kill and cut and cap: 20-40; after cut and cap: 35-45. Table is what is used as input.

After DOE - 35-60 provided to NIC.

Discussion about non-circularity of exit orifice. Not thought to be as important as the ratio.

**12:45-1:15 Dan Maclay Reservoir - Time of Event with Production**

Established to develop reservoir inflow as a function of flowing BHP for the Macondo reservoirs and provide results to the Nodal Analysis Team. Also to coordinate independent estimates.

Tight timelines for analyzing the results.

3D seismic data (slide 25) - structure maps constructed. Teams used "channel-levee complex" interpretation. Sheet sand model used for maximum extent case.

Assumptions: slide 28. Multiple multiphase flow models tested (significant differences).

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Concerns: slide 29. Seismic interpretation, permeability, unknown size, flow path uncertainty.

To get results, all teams had to conduct nodal analyses.

Some results (Kelkar) have low values that should be dropped. Results in slide 33 have not excluded those low numbers.

Size didn't matter up front, but later in time it did.

Discussion on depletion: BP analysis shows about 110M BBL in place. This would result in some depletion later in the record (not much in the first month, though).

**1:15-2:00 George Guthrie Nodal Analyses - Pre/Post Cut**

Facility calculations and fluid flow calculations: Well, BOP, etc., are the focus. Were supposed to couple with reservoir team, because they need to be coupled for a legitimate analysis (the problem is, in fact, coupled).

5 independent teams, followed by integration meeting and statistical analysis by NIST.

Used three well flow scenarios.

Inflow Performance Relationship (IPR) used along with nodal analysis that uses the wellbore performance relationship.

Team needed to develop its own IPR from a reservoir model because info from the reservoir team would not arrive until late in the game. Assumed no depletion. Used skin effect (damage at wellbore/reservoir interface).

BOP details not considered. Discussion on how it was handled. Teams used BOP delta P based on May 25 measurement, but different teams handled it differently, leading to different pressure drops in the individual analyses. But there may be a problem with the assumptions of the BOP and the impedance provided by the partially functioning rams.

Slide 48 results: Low estimates and high estimates from each Lab.

BOP: If test rams are really good, all flow must go through the drill pipe (much more restriction). The models do not consider this factor, making the analyses suspect.

**2:00-2:15 Break**

**2:15-2:45 Andy Bowen Doppler Velocities - Kink and more**

Imaging sonar and ADCP (Acoustic Doppler Velocity Profiler). ROV positioned 3 m from plume for velocity measurements, imaging sonar was 7 m away.

3D reconstruction of velocity field - slide 61 (vertical V in m/s).

Measurement allows one to look through the plume.

Uncertainties: field of view, non-symmetric plume shape, acoustic shadowing, detection threshold.

Result: slide 65 - 59.2k bbl/d (riser 40.7, BOP kink 18.5).

Uncertainties - slide 66: narrow time window, natural variability.

**2:45-3:15 Paul Hsieh Reservoir Studies Around Times of Well Integrity Test Shut-in**

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Shut in data analyzed to determine reservoir geometry and permeability, and then flow rate. Simplified way to analyze compared to reservoir and nodal teams, but allows for incorporation of shut in data.

Slide 70: reservoir properties and geometry.

Rock compressibility is important - 6, 12, and 15  $10^{-6}$  psi<sup>-1</sup>  
Performed optimizations.

Slide 71 - shows reservoir depletion

Slide 72 - Horner plot. Good matches

Slides 73, 74 shows time varying flow rates

Flow rates go from about 60 at early times to 50 near the end.

Analysis is grounded in the shut-in data. Rock compressibility and "no aquifer support" are the key assumptions.

### **3:15-4:00 Art Ratzel Flow prediction around Well Integrity Shut-in**

3 ram capping stack - slide 78. All above the BOP, so don't have to deal with it's complexity.

3 methods - slide 80

Clean geometry, 2 pressure gauges, surface vessel recoveries during some periods.

Assumptions: reservoir pressure, and depletion estimates, steady state

Uncertainties: multiphase flow models and EOS. K-factors are uncertain.

Slide 82 - choke pressures under different flow conditions through kill line

Delta pressure analysis (method 1): 52.6 to 52.9, bounds are 48 to 58. Eliminates geometric effects, which simplifies things greatly (slide 84)

Kill line analyses (method 2): flow through kill line, with all the complexities of the piping system. Slide 87: 2 groups (SNL and LLNL) both got about 48 to 51. Avg - 47-52

Choke line analyses (method 3): slide 90 data. March through as valve is shut. 3 Labs analyzed, similar results. Calcs. All showed flow increases as valves are shutting.

Counterintuitive, still looking at why.

Slide 95 - summary of 3 methods. Full open will probably allow for bounds (53 plus minus 5-10 bbl/d), but problem of 2 phase flow calcs.

What does this mean for results at earlier times? Slide 99 - full models can be built

Slide 107 summary: 53k from shut in; working backwards, about 65k on day 1.

Need more work to nail down 2 phase flow issues. Could be a transition from 2 phase to single phase as pressure increases.

### **4:00-5:00 Tom Hunter Discussion and Close-out**

Steven Chu: unknowns in plume team include pipe configuration (some flow in drill pipes, unknown how the flows are split inside the BOP). Could not tell the difference between 0 collection and 15k. When collecting 27k, still a lot of oil pouring into the ocean. This sets the lower bound.

Nodal: a lot more information on reservoir now. Also, no leak observed now in upper part of the well. Damage in well has to be further down. BOP - need to look at



self consistency. Pressure differences (added data) must be examined to ensure consistency with new data.

"Long road ahead of us" is not what he wants to hear. Where might method 1 go wrong? Can we use it. Once the sealing cap was on, much cleaner situation. Some methods have more wildcards in them.

Marsha McNutt: Need to put all scientific uncertainty on the estimates. Chu agrees.

Tom Hunter: 7 different calcs., 2 outliers are PIV and scenario 2 of nodal group. Others are in 50's.

Chu: for sake of nodal guys, need to go back in put in other information. Flow coming up riser and annulus (Scenario 1 and 2 together). Maybe got the right answer for the wrong reasons. Didn't take into account the rams that might have been working pretty well.

Talked about the purpose of the future work. Oil budget is the reason.

Chu: why do we want a number? Oil budget (10 or 20%); damages charged to BP (high accuracy not needed there either). Anything below 10% uncertainty is overkill. Time to complete? If getting from 15 to 10% takes a week, that may be too long. Taking weeks and weeks to refine is not acceptable.

Hunter: each team gives depletion vs. time and depletion vs. flow.

Reservoir, nodal, and Paul Hsieh teams: examine impact of well depletion on flow and confirm that low 50's value at day 87 before sealing is consistent with their results.

Path forward: assume day 87 low 50's, impact of depletion on flow. Reconvene

Chu: DHS Sec. and others wants oil budget this weekend. Need number by mid-afternoon tomorrow. Rumors related to oil unaccounted for. Need this number to bound the amount unaccounted for.

Chu: by 1 pm tomorrow conference call, two items:

Flow vs. depletion

Flow vs. time based on depletion

Change in flow between riser removal and capping stack (day 87 flow).

Hunter: 53 at day 87, going back linearly to 63 at time 0. What's wrong with that?

Chu: meet at 1 tomorrow with whatever new information we have, and finalize a flow rate versus time estimate.