From: Hill, Trevor
Sent: Wed Apr 28 12:49:52 2010
To: Birrell, Gordon Y
Cc: Austin, Julian; Tooms, Paul J; Nichols, Mark
Subject: RE: Action Items from 3:00 PM Sunday telecon - flow modeling
Importance: Normal
Attachments: Modeling of system flow behaviour rev 1.doc

Gordon

As requested via Julian please see the attached short note on modeling of flow through the system. Please let me know if this does not cover the full intent of your question. We have modeled the whole system from reservoir to sea in order to bound the answers on flowrate.

Regards
Trevor

From: Austin, Julian
Sent: 28 April 2010 08:44
To: Hill, Trevor; Lockett, Tim; Stilwell, Ian
Subject: RE: Action Items from 3:00 PM Sunday telecon

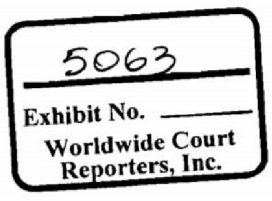
All,

Are you able to respond to Gordon's request below? I guess if using the whole well model you would need to adjust the downhole conditions to get the desired wellhead pressures - are you able to simply add the wellhead pressures as a boundary condition? I've attached the chart I created from Adam Ballards sims and yours, which I quadratically extrapolated to a leakage rate of 70mbd which is what Gordon was after. Perhaps these sims could cover that range also, bearing in mind this info will be required by early this am US. Maybe you are able to scale based on pressure?

Trevor, please call if there is any difficulty in getting this done quickly.

Kind regards,
Julian

From: Birrell, Gordon Y
Sent: 28 April 2010 01:27
To: Austin, Julian; Tooms, Paul J; Nichols, Mark
Subject: RE: Action Items from 3:00 PM Sunday telecon



Julian,

Thanks – can you please add curves for a range of well head pressure say 500, 1000, 2000, 3000, 4000,

5000, 6000, 7000, 8000psi

Thanks

Gordon

From: Austin, Julian
Sent: Tuesday, April 27, 2010 3:44 PM
To: Birrell, Gordon Y; Petruska, David J; Owen, Les L; Tooms, Paul J; Cook, Howard H; Nichols, Mark; Evans, Geoff; Neilson, Ian; Tognarelli, Michael A; Pattillo, Phillip D; Beynet, Pierre A
Cc: Parks, Megan
Subject: RE: Action Items from 3:00 PM Sunday telecon

Gordon,

Here is the orifice vs leakage rate calculation you requested based on both the local kink model and the entire riser/downhole system - the models agree well. I've plotted against both orifice diameter and orifice area for convenience.

Kind regards,
Julian

From: Birrell, Gordon Y
Sent: 27 April 2010 16:35
To: Austin, Julian; Petruska, David J; Owen, Les L; Tooms, Paul J; Cook, Howard H; Nichols, Mark; Evans, Geoff; Neilson, Ian; Tognarelli, Michael A; Pattillo, Phillip D; Beynet, Pierre A
Cc: Parks, Megan
Subject: RE: Action Items from 3:00 PM Sunday telecon
You may have this already but Megan Parks in Houston is doing doc control including issuing doc nos – pls contact her for nos.

Rgds

Gordon

From: Austin, Julian
Sent: Monday, April 26, 2010 2:32 PM
To: Petruska, David J; Birrell, Gordon Y; Owen, Les L; Tooms, Paul J; Cook, Howard H; Nichols, Mark; Evans, Geoff; Neilson, Ian; Tognarelli, Michael A; Pattillo, Phillip D; Beynet, Pierre A
Subject: RE: Action Items from 3:00 PM Sunday telecon

All,

Does anyone know if we have any project control or templates for documentation set up yet?

Thanks,
Julian

From: Petruska, David J
Sent: 26 April 2010 19:30
To: Petruska, David J; Birrell, Gordon Y; Owen, Les L; Tooms, Paul J; Cook, Howard H; Nichols, Mark; Austin, Julian; Evans, Geoff; Neilson, Ian; Tognarelli, Michael A; Pattillo, Phillip D; Beynet, Pierre A
Subject: Action Items from 3:00 PM Sunday telecon
All,

Action items from meeting:

1) Andy had concern if flow rates are wrong and are really much higher. Action to look into system and what other choke points may exist (unassigned, suggest Phil).

2) Concerns around the data we are using and how much confidence we can place on that. Paul to get Lynn Saha to be data conduit and QA.

3) Gordon to connect Mike with someone who can step him through survey data (likely John Hughes).

4) Group needs to come up with request list. Put in writing and send to Gordon.

5) Les to have some pipeline plugging solutions by morning.

Modeling of system flow behaviour (reservoir to sea)

There are four data points in which we have good confidence... reservoir pressure of ~12000 psi, seabed water pressure of ~2250 psi, fluid properties (bubble point ~6600 psi, gas-oil ratio ~2800 scf/bbl, and fluid composition), and flow path to sea being out of the full bore of the riser.

We are currently less certain of the following aspects, and need to keep abreast of the up-to-date view on each in order to maintain the best available model of the system:

- in-flow performance both prior to incident and after any formation damage that could have occurred during the incident
- flow path from sand face to mud line, whether this is through the drill pipe or up the casing string
- flow path through the BOP stack and into the riser, particularly on the effect of the kink and whether flow is in the drill pipe or in the riser... we are closely connected to the work under way by Julian Austin on modelling both of these flow paths
- flow path through the riser, whether flow remains in the drill pipe for most of the riser until a break in the drill pipe (particularly whether flow is in the drill pipe through the floating riser highpoint), or is discharged into the riser anywhere upstream of the highpoint

The current system model is set up with 5.625" ID pipe in the whole well (slightly conservative, given smaller IDs lower down) to the top of the BOP stack, with an orifice at the top of the stack, and then with the option of flowing either through the full bore of the riser (19.5" ID) or in the drill pipe until just before the exit to sea.

The predictions for flow rate and wellhead flowing pressure as a function of orifice size are given below (for the two post BOP cases of flow through drill pipe and flow through full bore riser). The model solves for flowrate and wellhead flowing pressure, given the orifice size and the inlet and outlet boundary conditions of reservoir and seawater pressure respectively.

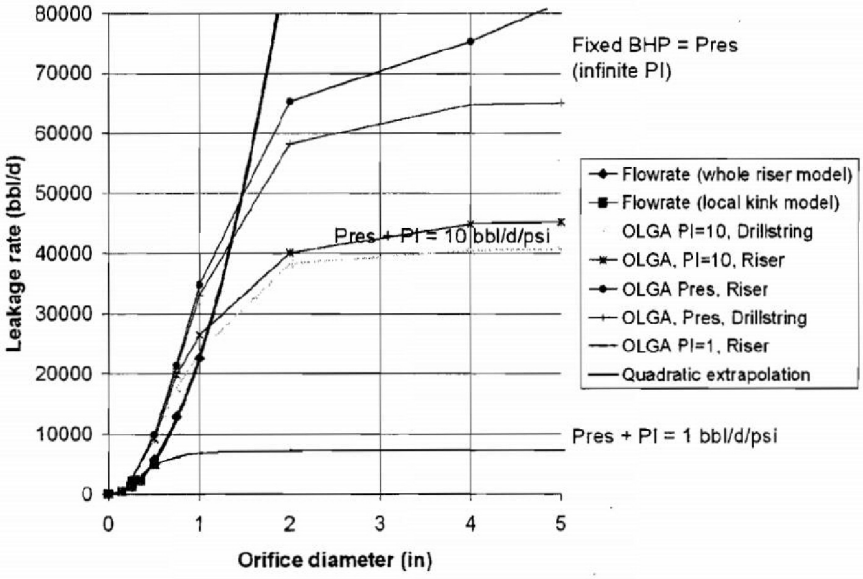
The further variable of reservoir in-flow performance is also modelled with three illustrative values, 1 bbl/d/psi, 10 bbl/d/psi and fixed bottomhole pressure. The last of these three shows the maximum hydraulic capacity of the system from bottomhole to sea and is a theoretical-only worst case. In reality the reservoir will always impose some resistance to flow, given by the illustrative values of 1 and 10 bbl/d/psi. We need the view of Macondo subsurface modeller and well designer to give us their view of the most appropriate value.

The data generated takes the form of the following illustrative table:

Orifice size inches diam	Flowrate stock tank bbl/day	Wellhead flowing pressure, psi	Flow path
0.25	2523	8557	All Drill string
0.5	9840	8514	
0.75	20888	8170	
1	33184	7472	
2	58284	4984	
5	65171	4179	

The greater the well inflow restriction the lower the available tubing head pressure, and the lower the resulting flowrate for a given size of orifice.

Cases modelled to date are shown on the following graph, (together with previous quadratic estimate):



Comments on the graph:
Orifice size dominates when small
Inflow performance dominates when orifice is greater than 1 inch
Drill pipe vs riser full bore only significant for the higher flowrates

We should also look at any video of the plume to see if we can make an estimate of flowing velocity. Preliminary calculations suggest a flowing mixture velocity of ~0.5 m/s for 10 mbd oil and associated gas leaving the riser at sea water pressure.

Trevor Hill, Tim Lockett
April 28, 2010