From: "Baker, Kate H (Swift)" <Kate.Baker@bp.com>
Sent: Friday, July 02, 2010 7:34:34 PM
To: <srtiesz@sandia.gov>; <pnelson@usgs.gov>; <pahsieh@usgs.gov>; <mooney@usgs.gov>; "Catherine B Enomoto/CD/USGS/DOI" <cenomoto@usgs.gov>; <srtiesz@sandia.gov>; <hickman@usgs.gov>; "Mark A. Havstad" <havstad1@llnl.gov>; "Morrow, Charles W" <cwmorro@sandia.gov>; "Dykhuizen, Ronald C" <rcdykhu@sandia.gov>; "Ammerman, Curtt N. (LANL)" <ammerman@lanl.gov>
CC: "Wells, Kent" <kent.wells@sel.bp.com>
Subject: Science Call Follow-Up

Attachments: Attachment

We had an action from the Macondo Shut-In & Well Test Protocol Meeting to ensure that the National Labs and USGS scientists had a file note on depletion, and this came up again on the Science call. Here is the file note on depletion.

<<Macondo Technical Note - Depleted Pressures vC.ZIP>> .
- Macondo Technical Note - Depleted Pressures vC.ZIP

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Macondo Technical Note

Title:	Depleted Pressure
Contributors:	
Issued by:	
Date:	July 1, 2010
Version:	C – DRAFT

Question Addressed in this Technical Note:

Discussions with the National Laboratories and other teams has resulted in a request for an estimated reservoir pressures for the Macondo field. This note provides the reservoir pressures calculated for the case in which the reservoir has produced at constant 35,000 stb/d from 20-April to 1-July.

Key Conclusions

Well Block Pressures at shut-in on 1-July-2010

Depletion 35mbd from 4/20/2010 (cumulative prodn: 2.52 mmstb total production)

Reservoir Section	Top Depth ftTVDSS	Near Well Pressure psia	Reservoir Pressure psia	Comment
M110	8,969	4,730	4,730	gas sand at 18" shoe (depth of 18" shoe)
M57B	17,381	10,875	11,567	gas sand (cross flow)
M57C	17,614	11,397	12,875	gas sand (cross flow)
M56A	17,718	10,248	9,895	gas sand (cross flow)
M56B	17,890	10,846	10,878	water sand (little flow)
M56C	17,944	11,059	11,771	water sand (little flow)
M56D	17,981	10,921	11,539	oil sand
M56E	18,034	10,842	11,258	Main Oil Sand (on which 11,850 psia is based)
M56F	18,132	10,939	11,524	oil sand

Note: all pressures hydrocarbon pore volume weighted at mid-point of reservoir layer

These calculations were repeated with crossflow between the deep sands and the M110. For the purposes of this exercise the M110 sands were made effectively "infinite" (using a pore volume multiplier) to minimize the impact of increasing reservoir pressure:

Well Block Pressures at shut-in on 1-July-2010 (With Crossflow to M110 Sand)
Depletion 35mbd from 4/20/2010 (cumulative prodn: 2.52 mmstb total production)

Reservoir Section	Top Depth ftTVDSS	Near Well Pressure psia	Reservoir Pressure psia	Comment
M110	8,969	5,503	4,731	gas sand at 18" shoe (depth of 18" shoe)
M57B	17,381	9,863	10,846	gas sand (cross flow)
M57C	17,614	10,756	12,788	gas sand (cross flow)
M56A	17,718	9,067	8,744	gas sand (cross flow)
M56B	17,890	9,955	9,957	water sand (little flow)
M56C	17,944	10,349	10,454	water sand (little flow)
M56D	17,981	9,996	11,229	oil sand
M56E	18,034	9,800	10,644	Main Oil Sand (on which 11,850 psia is based)
M56F	18,132	9,991	11,164	oil sand

Note: all pressures hydrocarbon pore volume weighted at mid-point of reservoir layer
M110 Sand modelled as effectively "infinite", hydrocarbon PV = 0.6x10^12 reservoir bbls

All pressures are reported 0.1 days (2.4 hours) after shut-in.

Assumptions

1. The calculation was performed using a VIP simulation model with the following parameters:
   - Oil B_{oi}: 2.345 rb/stb
   - c_f: 6 x 10-6 $psia^{-1}$
   - c_w: 3 x 10-6 $psia^{-1}$
   - GOR: 2993 SCF/stb
   - OOIP: 109.9 mmstb
   - Reservoir Volumes: Oil: 257.8 mmrb, S_{wc}: 9.7% (in M56E, varies in other zones), Aquifer: 991.6 mmrb (excludes connate water, 3.8x oil volume)

2. The model is a stylized representation of the reservoir, with each layer homogeneous, and no dip.
   - The "near well pressure" is taken from the well's gridblock, with dimensions of 100 x 100 ft.
   - The model includes the M57(B, C) and M56(B, C, D, E, F) sands, and was originally created to address whether the wellbore could become gas filled during shut-in at the "topkill."
   - The M57 gas sands have a higher initial pressure than the main oil sands; they are modelled with a limited areal extent. These sands contribute some flow for the first 10 days of production, during which time the predicted GOR drops from 4,600 SCF/stb to 3030 SCF/stb.
   - For depletion with only the M56D-F open, depletion at a constant 35 mbd would yield a near well pressure in the M56E of 10,889 psia, and there would be no change in the sand's average pressure.

3. Reservoir sands' properties and depths were modelled per spreadsheet "MC252 – 1 Sand Description v2.xls", (24-May, email Kelly McAughan, attached). The sands without permeability but calculated porosity were assigned a nominal permeability (see table).

4. The "skins" on all reservoir intervals were set to 0, in order to maximise the impact of crossflow. The largest crossflow rates (at the sandface in reservoir barrels/day) were:

• No shallow crossflow:	M56A:	-7,000 rb/d
.	M56E:	4,000 rb/d
• Shallow crossflow:	M110:	-49,000 rb/d
.	M56E:	41,000 rb/d

Reservoir Properties

Top of Sand MD Depth	Bottom of Sand MD Depth	Top of Sand TVDSS Depth	Bottom of Sand TVDSS Depth	Fluid Content	Expected to flow (Used in Modeling)	Sand Name	Gross Sand	Net Sand	Pay Sand	Average Gross Porosity	Average Net Porosity	Average Pay Porosity	Average Net Sw	Average Pay Sw	Arithmetic Air Perm	Geometric Air Perm	Geometric Perm converted to Oil (85%)	Perm Used in Model	Temperature	Pressure	Pressure Depth Datum
Feet	Feet	Feet	Feet				Feet	Feet	Feet	%	%	%	%	%	MD	MD	MD	mD	Degrees F	psia	Feet TVDSS
12030.0	12246.0	11945.0	12161.0	Gas	Yes if Liner Leak	S023	2	2	2								1000	N/A	162	7081 psia (based on 11.3 ppg pore pressure)	12053
13227.2	13230.2	13141.6	13144.6	Gas	Yes if Liner Leak	S026	3	3	3								1000	N/A	178	8405 psia (based on 12.3 ppg pore pressure)	13143
17467.0	17469.0	17361.1	17383.1	Gas	Yes	M57B	2	2	2	17.95	17.95	17.95	51.58	51.58	15.08	7.5	7.50	7.5	234	12847 psia (based on post well 14.2 ppg pore pressure)	17382
17700.0	17708.5	17614.1	17622.6	Uncertain	No	M57C	8.5	0	0	8.95								0.1	237	13017 psia (Geo tap @ 17713' tvdss) (MDT 3 attempts no seal)	17713
17804.0	17806.5	17718.1	17720.6	Oil or Gas	Yes	M56A	2.5	2.5	2.5	22.48	22.48	22.48	24	24	1702.07	467.39	397.28	397.3	239	12038 psia (one MDT pressure at 17721' tvdss)	17721
17975.5	17989.5	17889.6	17903.6	Brine	No	M56B	5	3	0	14.18	16.99		57.65		7.43	3.12		3.0	241		
18090.0	18032.0	17944.1	17946.1	Brine	No	M56C	2	2	0	17.28	17.28		64.2		4.73	4.05		4.0	241		
18067.0	18089.0	17981.1	18003.1	Oil	Yes	M56D	22	22	22	20.67	20.67	20.67	17.17	17.17	257.67	101.8	86.53	86.5	242	11838 psia (MDT & Geotap)	17993
18120.0	18191.0	18034.1	18105.0	Oil	Yes	M56E	69.5	64.5	64.5	21.42	22.08	22.08	9.7	9.7	514.04	323.79	275.22	275.2	245	11856 psia (MDT)	18065
18217.5	18238.5	18131.5	18152.5	Oil	Yes	M56F	6.5	6.5	6.5	21.08	21.08	21.08	21.85	21.85	1440.59	129.87	110.39	110.4	244	11875 psia (based on fluid gradient 0.568 gm/cc)	18142
								Vsh<0.4	Poro>0.14	Sw<0.5	Vsh<0.4	Poro>0.14	Sw<0.5									
If Density log is not corrected to match core porosity																					
18067.0	18089.0	17981.1	18003.1	Oil	No Use Other	M56D	22	22	22	18.32	18.32	18.32	18.55	18.55	20.96	10.46	26.06				

1. From core in M56D and M56E: K (klinkenberg air core at net confining stress = 2000 psi) is a function of core porosity at net confining stress
2. Log porosity is calibrated to core porosity at net confining stress in M56D & M56E
3. Log perm is calculated from core derived equation (from #1)

Gross has Vshale cut off Vsh<0.4
Net has a Porosity cut off Poro>0.14
Pay has a Sw cut off Sw<0.5

Water Depth = 4992 feet