



Macondo Technical Note

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| Title: | Depleted Pressure for Well Control Planning |
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| Issued by: | Bob Merrill |
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| Version: | C – DRAFT |

Question Addressed in this Technical Note:

The team planning the relief well has requested a revised estimate of the pressures which they may encounter at the reservoir interval.

This note differs from Version B in two aspects: 1) it addresses questions from the drilling team regarding pressures in the M57 sands, and 2) it incorporates simulation results to 22-July (the previous note included simulated results to 2-July).

Key Conclusions

The likely pressure in the M56E (main oil sand) is approximately 10,100 psia. This value is based on the pressure observed at the BOP, corrected for static head. This new estimate lies within the previously estimated range for this sand, 9,360 – 10,550 psia (ref. note: “Depleted Pressure for Relief Well Planning” vA, 2-July-2010, by Bob Merrill)

The pressures in the M57 interval are expected to be considerably higher than the pressure in the M56E, for the following reasons:

- The sands may or may not be producing, which raises the possibility that they could be at initial pressure. Communication between these sands and the wellbore is unknown, but we assume that the sands are open to flow.
- These sands were logged as low permeability sands (7.5 mD and 0.1 mD in the B and C, respectively). The flow potential of these sands is quite low. Both were encountered slightly overpressured, which suggests limited areal extent.

The M56A sand, on the other hand, is likely to be depleted relative to the M56E. The fluid in the sand is uncertain (either gas or oil). We have modeled it as a gas, and it has considerable flow potential (logged permeability: 400 mD).

These conclusions can be summarized in the following table:

Calculated Reservoir Pressures on 20-July

| Zone | Mid-pt TVDss (ft) | Modeled Fluid | Mobility (KH/0) | Wellbore (psia) | Near Wellbore | Reservoir (psia) | Near Wellbore | |
|------|-------------------|---------------|-----------------|-----------------|---------------|------------------|-----------------------|----------------------|
| | | | | | | | Minimum (60mbd/no Ag) | Maximum (35 mbd/+Ag) |
| M57B | 17,362 | Gas | 200 | 9,893 | 10,790 | 11,353 | 10,111 | 11,324 |
| M57C | 17,619 | Gas | 13 | 9,951 | 11,827 | 12,877 | 11,402 | 12,162 |
| M56A | 17,719 | Gas | 13,240 | 9,976 | 8,620 | 8,008 | 7,104 | 9,814 |
| M56B | 17,897 | Water | 43 | 10,019 | 10,764 | 11,272 | 10,179 | 11,224 |
| M56C | 17,945 | Water | 23 | 10,031 | 11,147 | 11,991 | 10,663 | 11,528 |
| M56D | 17,992 | Oil | 8,458 | 10,043 | 10,555 | 11,206 | 9,703 | 11,225 |
| M56E | 18,070 | Oil | 79,058 | 10,062 | 10,100 | 10,363 | 8,897 | 11,047 |
| M56F | 18,142 | Oil | 3,191 | 10,079 | 10,503 | 11,090 | 9,579 | 11,230 |

- “Wellbore” pressure is based on a static head from the observed BOP pressure (6850 psia). In high mobility zones, this pressure will approximate the reservoir pressure. This is not the case for lower mobility zones.
- “Near well” and “reservoir” pressures are based on a weighted average of simulation cases.
 - “Near Well” represents the pressure within 20ft of the wellbore
 - “Reservoir” represents the average reservoir pressure
- “Extreme” cases are shown; these represent the calculated maximum and minimum “Near Well” pressures.

For completeness, the following table includes the static wellbore pressures calculated at each of the casing points:

| Shoe or Formation | Depth MD | Depth TVD | SIP (Prosper thermal) | IP (from gauge) |
|-------------------|----------|-----------|-----------------------|-----------------|
| Mudline | 5,067 | 5,067 | 6,855 | 16 |
| 36" | 5,321 | 5,321 | 6,920 | 81 |
| 28" | 6,217 | 6,217 | 7,146 | 307 |
| 22" | 7,937 | 7,937 | 7,572 | 733 |
| 18" | 8,969 | 8,969 | 7,826 | 987 |
| 16' | 11,585 | 11,585 | 8,469 | 1,630 |
| 13-5/8' | 13,145 | 13,133 | 8,850 | 2,011 |
| 11-7/8" | 15,103 | 15,092 | 9,331 | 2,492 |
| 9-7/8" | 17,168 | 17,157 | 9,838 | 2,999 |
| Top M57B | 17,467 | 17,381 | 9,893 | 3,054 |
| Top M57C | 17,700 | 17,614 | 9,950 | 3,111 |
| Top M56A | 17,804 | 17,718 | 9,975 | 3,136 |
| Top M56B | 17,976 | 17,890 | 10,017 | 3,178 |
| Top M56C | 18,030 | 17,844 | 10,006 | 3,167 |
| Top M56D | 18,067 | 17,981 | 10,040 | 3,201 |
| Top M56E | 18,120 | 18,034 | 10,053 | 3,214 |
| Top M56F | 18,218 | 18,132 | 10,077 | 3,238 |
| 7" | 18,304 | 18,293 | 10,116 | 3,277 |
| TD | 18,360 | 18,349 | 10,130 | 3,291 |

Assumed Pressure: 6850 psia at capping stack
 Pressure of 6839 recorded at the BOP (5046 ft) at 23:56 on 20-July

Assumptions / Discussion

1. The wellbore pressures are based upon a static head. The others are based upon simulation.
2. Reservoir Parameters for simulation (unchanged from previous note):
 - Oil B_{oi} : 2.345 rb/stb
 - c_f : 6×10^{-6} psia⁻¹
 - c_w : 3×10^{-6} psia⁻¹
 - GOR: 2993 SCF/stb
 - OOIP: 109.9 mmstb
 - Reservoir Volumes: Oil: 257.8 mmb, S_{wc} : 9.7% (in M56E, varies in other zones), Aquifer: 991.6 mmb (excludes connate water, 3.8x oil volume)
3. Average depletion for each case (psi/day) from 20-April to 1-July were calculated. This factor was applied to the simulation results (through 1-July) to update them to 20-July.
4. The model is a stylized representation of the reservoir, with each layer homogeneous, and no dip.
5. 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).

Reservoir Properties

| Top of Sand MD Depth | Bottom of Sand MD Depth | Top of Sand TVD-SS Depth | Bottom of Sand TVD-SS Depth | Fluid Contact | Expected to Flow (Based on Modeling) | Sand Name | Gross Sand Feet | Net Sand Feet | Pay Sand Feet | Average Gross Porosity % | Average Net Porosity % | Average Pay Porosity % | Average Net Permeability md | Average Pay Permeability md | Arithmetic As Perm. md | Geometric As Perm. md | Geometric Permeability Converted to Oil (65%) md | Pore Volume in Place bbl | Temperature Degrees F | Pressure psia | Pressure Gradient psia/ft | |
|----------------------|-------------------------|--------------------------|-----------------------------|---------------|--------------------------------------|-----------|-----------------|---------------|---------------|--------------------------|------------------------|------------------------|-----------------------------|-----------------------------|------------------------|-----------------------|--|--------------------------|-----------------------|---|--|-------|
| | | | | | | | | | | | | | | | | | | | | | | Feet |
| 12030.0 | 12248.0 | 11945.0 | 12181.0 | Gas | Yes if Linear Leak | S023 | 2 | 2 | 2 | | | | | | | | 1000 | N/A | 162 | 7081 psia (based on 11.3 ppg pore pressure) | 12033 | |
| 13227.2 | 13239.2 | 13141.8 | 13144.8 | Gas | Yes if Linear Leak | S028 | 3 | 3 | 3 | | | | | | | | 1000 | N/A | 178 | 8406 psia (based on 12.3 ppg pore pressure) | 13143 | |
| 17467.0 | 17469.0 | 17391.1 | 17383.1 | Gas | Yes | M57B | 2 | 2 | 2 | 17.95 | 17.95 | 17.95 | 51.58 | 51.58 | 15.08 | 7.5 | 7.50 | 7.0 | 234 | 12847 psia (based on post well 14.2 ppg pore pressure) | 17282 | |
| 17700.0 | 17708.5 | 17614.1 | 17622.8 | Uncertain | No | M57C | 8.5 | 0 | 0 | 8.95 | | | | | | | | 0.1 | 237 | 13017 psia (Geo log @ 17713' tvds) (MDT 3 attempts to seal) | 17713 | |
| 17804.0 | 17809.5 | 17718.1 | 17720.8 | Oil or Gas | Yes | M59A | 2.5 | 2.5 | 2.5 | 22.48 | 22.48 | 22.48 | 24 | 24 | 1702.07 | 487.36 | 397.28 | 397.3 | 239 | 12038 psia (one MDT pressure at 17721' tvds) | 17721 | |
| 17975.5 | 17989.5 | 17889.6 | 17903.6 | Brine | No | M59B | 5 | 3 | 0 | 14.18 | 16.99 | | 57.65 | | 7.43 | 3.12 | | 3.0 | 241 | | | |
| 18030.0 | 18032.0 | 17944.1 | 17948.1 | Brine | No | M59C | 2 | 2 | 0 | 17.29 | 17.28 | | 64.2 | | 4.73 | 4.06 | | 4.0 | 241 | | | |
| 18067.0 | 18089.0 | 17981.1 | 18083.1 | Oil | Yes | M59D | 22 | 22 | 22 | 20.87 | 20.87 | 20.87 | 17.17 | 17.17 | 257.87 | 101.8 | | 89.53 | 88.5 | 242 | 11838 psia (MDT & Geotap) | 17983 |
| 18120.0 | 18191.0 | 18034.1 | 18106.0 | Oil | Yes | M59E | 69.6 | 64.6 | 64.5 | 21.42 | 22.08 | 22.08 | 9.7 | 9.7 | 514.04 | 323.75 | | 275.22 | 275.2 | 243 | 11868 psia (MDT) | 18085 |
| 18217.5 | 18239.5 | 18131.5 | 18152.5 | Oil | Yes | M59F | 6.5 | 6.5 | 6.5 | 21.08 | 21.08 | 21.08 | 21.85 | 21.85 | 1440.59 | 128.87 | | 110.36 | 110.4 | 244 | 11875 psia (based on fluid gradient 0.568 gm/cc) | 18142 |

If Density log is not corrected to match core porosity
 18067.0 18089.0 17981.1 18003.1 Oil No Use Other M59D 22 22 22 18.32 18.32 18.32 18.55 18.55 28.98 10.46 28.96

- From core in M59D and M59E: K (Klinkenberg air core at net confining stress = 2000 psi) is a function of core porosity at net confining stress
- Log porosity is calibrated to core porosity at net confining stress in M59D & M59E
- Log perm is calculated from core derived equation from #1)

Gross has Vshale cut off Vsh=0.4
 Net has a Porosity cut off Poros=0.14
 Pay has a Sw-cut off Sw=0.6

Water Depth = 4992 feet

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