

**From:** "Norm McMullen" <[REDACTED]>  
**Sent:** Fri, 30 Apr 2010 17:10:02 -0500  
**To:** "Saidi, Farah" <farah.saidi@bp.com>, "Elizondo, Terry" <Theresa.Elizondo@bp.com>  
**Cc:** "Hill, Trevor" <trevor.hill@uk.bp.com>, "Lockett, Tim" <Tim.Lockett@uk.bp.com>, "Stan Nau" <stan.nau@bp.com>, "Liao, Tony T" <tony.liao@se1.bp.com>, "Cooling, Grace" <grace.cooling@bp.com>  
**Subject:** Re: An Update on Fluids  
**Priority:** Normal

See below. We will continue to use the current (bubble point) model for Flow Assurance until there is a compelling reason to switch to another.

Let me know any objections

Norm McMullen  
Flow Assurance Consultant

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----- Original Message -----

**From:** Hill, Trevor  
**To:** Lockett, Tim ; Norm McMullen  
**Sent:** Friday, April 30, 2010 4:28 PM  
**Subject:** FW: An Update on Fluids

F.y.i.

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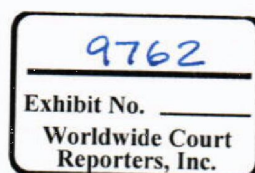
**From:** Wang, Yun  
**Sent:** 30 April 2010 22:10  
**To:** Hill, Trevor; Saidi, Farah; Petruska, David J; Nau, Stan R; Pattillo, Phillip D; Pattillo, David; Payne, Michael L; Corser, Kent; Liao, Tony T; Cecil, Chris; Cooling, Grace  
**Cc:** Mason, Mike C; Wilson, Roberta; Stephen, Alan G  
**Subject:** An Update on Fluids

An update on the fluids PVT and phase behavior understanding for Macondo, as of today, Friday, April 30th.

We received two sets of Constant Composition Expansion (CCE) data from Pencor (a subsidiary of Core Labs) in the afternoon of Wednesday, April 28th. One is under reservoir temperature of 243F, the other is under 100F. In addition, we received the single-stage flash data from Pencor yesterday afternoon (Thursday, April 29th). Below is a summary of the observations made after examination of the new data received:

1. The new single-stage flash data indicates that the two duplicate samples from the same depth (MD 18,142') have a GOR of 2,819 scf/stb and 2,802 scf/stb, respectively, in good agreement with the on-site mobile lab GOR of 2,840 scf/stb and my Equation Of State (EOS) model calibration of 2,847 scf/stb. The new single-stage flash data does suggest slightly higher GOR for samples from the other

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two depths (MD 18,086' and 18,124'). They range from 2,875 scf/stb to 3,063 scf/stb. As of today the only data we have for samples from the other two depths is the single-stage flash data.

2. The new single-stage flash data indicates that the two duplicate samples from the same depth (MD 18,142') have the same API of 35.2, in good agreement with the on-site mobile lab API of 35 and my EOS model calibration of 35.0. The new single-stage flash data suggests very similar API gravity for samples from the other two depths. They range from 34.6 to 35.0.

3. The new single-stage flash compositional data confirms that the on-site compositional analyses are consistent with the Pencor lab compositional analyses.

4. The new CCE data under reservoir temperature of 243F indicates a saturation point pressure of 6,504 psia, in good agreement with the preliminary Pencor number (reported to us as a bubble point pressure on Monday morning, April 26th) of 6,550 psia. It is also in good agreement with my EOS model calibration of 6,601 psia under 243F.

5. The new CCE data under reservoir temperature of 243F gives a single-phase fluid density of 0.57 g/cc at 10,000 psia, while my EOS model gives a straight prediction of 0.6027 g/cc at 10,000 psia without the benefit of single-phase density data calibration, which is not an unreasonable outcome.

6. The new CCE data under reservoir temperature of 243F indicates a highly unusual volumetric behavior, however. The CCE data seems to suggest a dew point system, though with maximum liquid dropout volume of 60%. The CCE data under 100F shows a similar behavior, with maximum liquid dropout volume of close to 70%. For your reference, a typical very rich, near-critical gas condensate would have a maximum liquid dropout volume of only 50%.

7. Upon receiving the data in Wednesday afternoon, I immediately requested the transfer of a duplicate sample from Pencor to Oilphase (a subsidiary of Schlumberger) to perform the same CCE test, in order to obtain an independent assessment. Alan Stephen (Fluids Advisor based in EPT Sunbury) and I came to the conclusion that this highly unusual volumetric behavior has never been observed for BP fluids samples anywhere else before, and that if it is indeed genuine phase behavior, it will be almost impossible to model using EOS. Discussions Alan and I have had with Pencor so far have not revealed any obvious lab procedural or operational issues that would explain the unusual volumetric behavior.

8. Oilphase has received the duplicate sample as of this morning and has started the restoration process. The actual CCE test could begin as early as next Monday. I will be present, along with other BP engineers, to witness the measurement. The test will have visual recording (either video or photo).

9. In terms of your modeling work that needs fluid data input, Alan and I believe that if your pressure is above 6,500 psia, the current EOS description is a reasonable model (it gives you reasonable GOR, API, single-phase density, and saturation pressure), with the exception of viscosity, which has not been included in the model. I have sent out the viscosity data in a separate email yesterday (see the email trail below). For pressures below 6,500 psia, until we have independent confirmation of the unusual volumetric behavior, we don't have a better interpretation than the current one, which models the fluid as a bubble point system based on the data as

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of Monday, April 26th.

Please do not hesitate to discuss with me or Alan Stephen if you have questions/concerns.

*Yun Wang, Ph.D.*

**Complex Fluids CoP Leader**

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<http://ssw.bpweb.bp.com/Networks/ReservoirFluids/tabid/885/Default.aspx>

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**From:** Wang, Yun

**Sent:** Thursday, April 29, 2010 11:38 AM

**To:** Hill, Trevor; Saidi, Farah; Petruska, David J; Nau, Stan R; Pattillo, Phillip D; Pattillo, David; Payne, Michael L; Corser, Kent; Liao, Tony T; Cecil, Chris; Cooling, Grace

**Cc:** Mason, Mike C; Wilson, Roberta; Stephen, Alan G

**Subject:** RE: Viscosity Data at Reservoir Temperature

All,

We just received the live reservoir fluid viscosity data at reservoir temperature from Pencor late yesterday. The undersaturated viscosities are below 0.2cp, the low end of EMV measurement capability. But the overall trend looks reasonable.

<< File: 36126-53 Preliminary Data.xls >>

Viscosity data at lower temperatures will come later.

*Yun Wang, Ph.D.*

**Complex Fluids CoP Leader**

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**From:** Wang, Yun

**Sent:** Tuesday, April 27, 2010 7:16 AM

**To:** Wang, Yun; Hill, Trevor; Saidi, Farah; Petruska, David J; Nau, Stan R

**Cc:** Epps, David S; Bozeman, Walt

**Subject:** RE: URGENT - Fluid Data

Please note that the EOS description below has NOT been calibrated with viscosity data since there isn't any yet. Pencor promised a dead oil viscosity data point today. As soon as I receive it, I will use BP's in-house correlation to generate synthetic viscosity variation with pressure for the same temperature as the dead oil viscosity is measured. Then the EOS description can be calibrated using Pedersen's corresponding state correlation in PVTsim, which has a better temperature dependence than other options.

*Yun Wang, Ph.D.*

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**From:** Wang, Yun

**Sent:** Monday, April 26, 2010 6:12 PM

**To:** Hill, Trevor; Saidi, Farah; Petruska, David J; Nau, Stan R

**Cc:** Epps, David S; Bozeman, Walt

**Subject:** RE: URGENT - Fluid Data

**Importance:** High

An update on this request:

1. We have received preliminary compositional data from Pencor:

<< File: 36126 Preliminary Wellstream.xls >> << File: BP Macondo Final Field Report.pdf >>

2. I have done a preliminary analysis of the data:

<< File: Preliminary\_Analysis.ppt >> << File: Preliminary\_EOS.fdb >>

To summarize the preliminary data and analysis:

- 1). All three live oil compositions are derived from mathematical recombination by Pencor using the on-site mobile lab GOR, which need to be confirmed in the PVT lab flash tests.
- 2). On-site GOR and API show little variation among the three samples from three depths (MD 18,086', 18,124' and 18,142').
- 3). The liquid and vapor compositions in Pencor's report have very reasonable K-value consistency (see

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slides 1,2,3).

- 4). The liquid analyses in Pencor's report indicate very little mud contamination, which is consistent with on-site report (see slide 4).
- 5). The liquid analyses in Pencor's report indicate very little variation among the three samples (see slide 4), which is consistent with the on-site GOR and API trend.
- 6). A preliminary 18-component EOS description has been developed to fit the data of sample 36126-44 from MD 18,142' (on-site GOR, API, Pencor bubble point and compositional analysis). The EOS description is contained in the attached PVTsim database file. The pseudo component thermal properties need to be sense-checked to ensure robust thermal calculation.
- 7). The phase envelope generated using the above EOS (see slide 5) indicates that this is an undersaturated volatile oil system.
- 8). Pencor indicated that their assertion of three hydrocarbon phases (1 vapor + 1 light liquid + 1 heavy liquid) in equilibrium under reservoir temperature and certain pressure range has not been substantiated by repeatable observations. Hence we should continue to model this undersaturated volatile oil as such until unequivocal evidence suggests otherwise.

All the above observations are preliminary and subject to revision pending Pencor's full PVT analysis results.

Please let me know if you have any questions.

*Yun Wang, Ph.D.*

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**From:** Wang, Yun

**Sent:** Monday, April 26, 2010 10:47 AM

**To:** Saidi, Farah; Petruska, David J; Nau, Stan R

**Cc:** Hill, Trevor

**Subject:** RE: URGENT - Fluid Data

Here is what I know so far:

1. Very low contamination samples (<1.0% wt STO) were collected from three depths, two of which have both MPSR and SPMC samples.
2. On site mobile lab indicated typical GOR of around 3,000 scf/stb
3. One MPSR sample analyzed in Pencor indicated a preliminary bubble point of 6,550 psia at 243F.
4. Visual observation from PVT cell indicated three hydrocarbon phases between 5,300 psia and 6,350 psia, unusual behavior for GoM oil and certainly very difficult to model.
5. Pencor promised preliminary reservoir live oil composition sometime today or tomorrow, but final flash test results won't be available until the middle to end of this week.

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I will pass along the preliminary composition data as soon as I receive it.

*Yun Wang, Ph.D.*

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**From:** Saidi, Farah

**Sent:** Monday, April 26, 2010 10:14 AM

**To:** Petruska, David J; Nau, Stan R

**Cc:** Hill, Trevor; Wang, Yun

**Subject:** RE: URGENT - Fluid Data

David,

Exploration has told Yun that actual good quality sample from Macondo is available and Pencor is working on the clock to provide the data. The data will be available either later today or tomorrow. According to the exploration reservoir engineer this reservoir has unusual fluid (not defined what that means) so using analog is not recommended. One complain that the Lab has had is that too many people are calling to inquire about this which is slowing them down. I recommend that we have a streamline effort on this so no mistakes or delays are made.

Yun,

Please add as needed to my note if I miss something.

*Regards,*

*Farah Saidi*

*GOM SPU Flow Assurance Technical Authority*

*BP*

*Office 281-366-5746*

*Cell [REDACTED]*

<< OLE Object: Picture (Metafile) >>

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**From:** Petruska, David J

**Sent:** Monday, April 26, 2010 9:12 AM

**To:** Saidi, Farah; Nau, Stan R

**Subject:** URGENT - Fluid Data

Farah, Stan,

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Do either of you have fluid data that may be a good analog to what we would expect to have in Macondo?  
If not can you tell me who may be some good people who I can contact to help chase this down. Trevor  
Hill is asking for it so if got any questions, please talk to him. Just keep me in the loop.  
Thanks,  
David

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