



RAILROAD COMMISSION OF TEXAS

OFFICE OF GENERAL COUNSEL

April 14, 2006

OIL AND GAS DOCKET NO. 03-0246609

APPLICATION OF BRIGHAM OIL & GAS L.P. TO CONSIDER NEW FIELD DESIGNATION FOR THE BOULDIN LAKE (LOWER FRIO) FIELD AND PERMANENT GAS WELL CLASSIFICATION FOR THE WYSE LEASE WELL NO. 1, MATAGORDA COUNTY, TEXAS

HEARD BY: Thomas H. Richter, P.E.

DATE OF HEARING: April 7, 2006

APPEARANCES:

REPRESENTING:

Dick Schmidt

Brigham Oil & Gas L.P.

EXAMINER'S REPORT AND RECOMMENDATION STATEMENT OF THE CASE

This is the unproteted application of Brigham Oil & Gas for Commission consideration of a new field designation to be known as the Bouldin Lake (Lower Frio) Field and designate the discovery well, the Wyse Lease Well No. 1, as a gas well and adopt the following field rules:

1. The entire combined correlative interval from 13,903' to 14,175' as shown on the Type Log of the Brigham Oil & Gas, Wyse Lease Well No. 1 (API No. 321-32040), C.R. Bostwick & R. Brotherton Survey, A-6, Matagorda County, Texas should be designated as the Bouldin Lake (Lower Frio) Field.
2. An allocation formula based on 75% deliverability and 25% per well.

It is also requested that any overproduction be cancelled. The Notice of Hearing proposed an allocation formula based on 75% deliverability and 25% acreage. Because a density is not being proposed, an allocation formula with acreage as part of the allocation formula is not appropriate. It was suggested by the examiner that the "acreage" be replaced with "per well". The applicant stated that this would not be considered adverse. It was also stated that though the application was brought forward by Brigham Oil & Gas, the subject well has been acquired by Penn Virginia Oil & Gas. The examiner recommends approval of the application.

DISCUSSION OF THE EVIDENCE

The Bouldin Lake (Lower Frio) Field was discovered by completion of the Brigham Oil & Gas, Wyse Lease Well No. 1 through 3 sets of perforations from 14,111' to 14,175' subsurface depth on April 16, 2005. The well potentialed at 2,918 MCFD and a calculated absolute open flow of 10,358 MCFD. A review was made of all wells within the 2.5 miles of the discovery well. The closest comparable production from same correlative Frio Sand is the Rugeley, SW. (12850) Field. The well in that field is perforated from 12,851' to 12,911'. Cross-section well log analysis indicates that there is a major fault separation with over 1,000' of throw displacement. There are numerous wells completed in the area in the Frio sands both higher and lower than the subject well. The Wyse Well No. 1 is located within its own fault block. The Frio Formation is complexly faulted in this area of the Gulf Coast. The entire combined correlative interval from 13,903' to 14,175' as shown on the Type Log of the Brigham Oil & Gas, Wyse Lease Well No. 1 (API No. 321-32040), C.R. Bostwick & R. Brotherton Survey, A-6, Matagorda County, Texas should be designated as the Bouldin Lake (Lower Frio) Field.

Because the proposed new field is combining multiple productive zones, a two-factor allocation formula is necessary for the protection of correlative rights pursuant to State Statutes. The proposed two-factor allocation formula based on 75% deliverability and 25% per well satisfies this requirement.

The Brigham Oil & Gas, Wyse Lease Well No. 1 in the Bouldin Lake (Lower Frio) Field should be permanently designated as a gas well. The well tested at 3,556 MCFD on a 10/64th choke flowing at 7,496 psig. The gas gravity is 0.710 and the condensate gravity is 48°API (color is amber). The initial gas/liquid ratio was 7,802:1. The original static reservoir conditions reported was 11,739 psig and 297°F.

Cumulative production through February 2006 is 77.5 MMCF of gas and 7,942 barrels of condensate. The current GOR is 7,388. The current producing rate is 120 MCFD and 11 BC/D.

Shortly after completion, Brigham Oil & Gas elected to have FESCO perform a PVT analysis on the subject well which Brigham Oil & Gas believe substantiates the permanent classification of gas well status because the well produces from a retrograde gas condensate reservoir.

The original static reservoir pressure was 11,739 psia at 297°F. The mechanical Constant Composition Expansion (CCE) results show a measured dew point pressure of 5,684 psig at 297°F. The reservoir fluid did exist as a single-phase system at initial reservoir conditions. Continued reservoir pressure reduction below the dew point will result in greater retrograde condensate liquid formation in the reservoir. Compositional analysis indicates the wellstream to be 71.16 Mole% methane and 6.365 Mole% heptanes plus. The CCE analysis measured the maximum hydrocarbon liquid volume in the two-phase envelope would occupy 6.63% of the hydrocarbon pore volume (HCPV) at 2,223 psig. Any liquid hydrocarbon in a reservoir is essentially immobile until it reaches a saturation of at least 10 to 20% depending on the rock type and several other reservoir and physical

factors. Typical retrograde gases contain less than 12.5 mol percent of Heptanes Plus and the stock-tank liquid gravities are between 40° and 60° API.

Brigham Oil & Gas believes the subject well should be classified as a gas well because the well does have a measured dew point pressure indicating the well to be a gas condensate well and no critical points were detected, the initial GOR was above 3300:1, the heptanes plus is less than 12.5 Mole%, the hydrocarbon liquid was between 40° and 60° and the maximum liquid hydrocarbon would occupy 6.63 % of the HCPV which is so low that it would not be mobile in the reservoir.

EXAMINER'S OPINION

The Texas Administrative Code, Title 16, Part 1, Chapter 3, Rule §3.69 Definitions Subsection (11)(C) and Statewide Rule 79 defines a gas well as "...A well which produces hydrocarbon liquids, a part of which is formed by a condensation from a gas phase and a part of which is crude petroleum oil, shall be classified as a gas well unless there is produced one barrel or more of *crude petroleum oil* (emphasis added) per 100,000 cubic feet of natural gas; and that the term "crude petroleum oil" shall not be construed to mean any liquid hydrocarbon mixture or portion thereof which is not in the liquid phase in the reservoir, *removed from the reservoir in such liquid phase* (emphasis added), and obtained at the surface as such."

The statute requires for a well with a gas-hydrocarbon liquid ratio of less than 100,000:1, a series of tests must be passed to be classified as a gas well. For prima facie gas well classification, the Commission uses the data from Form G-5 (Gas Well Classification Report) for a well and compares it to Commission Guidelines. The key guideline parameters are:

- * Gas-liquid hydrocarbon ratio of at least 12,500:1
- * API gravity of the liquid hydrocarbon of at least 50 degrees
- * On the ASTM Distillation Test of the liquid:

Initial Boiling Temperature must be less than 120°F

At 80% recovery, the boiling temperature must not exceed 520°F

The end point must not exceed 720°F with at least 95% recovery

To be classified as a gas well if the initial producing gas-hydrocarbon liquid ratio is less than 100,000:1, the following requirements must all be met:

- * There must be a measured dew point (condensation point), wherein the hydrocarbon liquid begins to form in the reservoir;

- * The liquid hydrocarbon that forms in the reservoir (condensate) must be immobile in the reservoir and not produced at the surface; and
- * No more than one barrel of crude petroleum oil per 100,000 cubic feet of gas is produced.

The Form G-5 shows that well failed the minimum GOR, the minimum API liquid gravity, the maximum 80% recovery temperature, the maximum end point temperature and minimum recovery percentage.

The subject well at original reservoir conditions was single phase undersaturated. According to the PVT CCE analysis, as the reservoir pressure continues to decline, a greater volume of liquid will condense from the gas phase into the pore space of the formation to a maximum of 6.63% of the HCPV.

Technically, anytime there is hydrocarbon liquid dropout in the reservoir, the well is a "retrograde gas condensate well". A true "wet gas" will not condense liquid until it is cooled. Reservoirs remain at constant temperature. If PVT analysis shows condensation with pressure reduction, then the reservoir is above the critical temperature. It is the critical temperature which dictates a gas condensate versus a volatile oil. The hydrocarbon liquid volume and gas composition in this case indicates a rich retrograde condensate. The classification of reservoirs properly depends upon (a) the composition of the hydrocarbon accumulation and (b) the temperature and pressure of the accumulation in the formation. Because compositions can vary in every conceivable proportion and the temperature and pressure gradient vary, the reservoir types may blend in with one another and even overlap. The presence of an oil zone will affect the accuracy of calculations based on a single-phase study.¹ The determination of an accurate dew point (or bubble point) is dependent upon several parameters. The correct recombination ratio of the collected gas and liquid from the separator should be as accurate as possible in the early life of the well. An incorrect dew point pressure may occur because an operator did not properly flow-condition the well before sampling. Ideally, a well should be cleaned up on a higher rate and then the well rate is lowered sequentially in stabilized rate steps to determine the lowest rate that completely unloads all fluids from the wellbore. Few operators take the time and expense to determine the best recombination GOR for laboratory work. The sampling should be performed in the early life of a well before pressure depletion effects the composition of the samples.

Retrograde gas-condensate reservoirs are unique and a general understanding of the geological and reservoir/chemical characteristics must be understood to differentiate a gas condensate reservoir from a volatile oil reservoir. Reservoir temperature is essential in the classification of the type of reservoir i.e. volatile oil or retrograde gas condensate. A fluid

¹ Applied Petroleum Reservoir Engineering, B.C. Craft and M.F. Hawkins, Petroleum Engineering Department, Louisiana State University, Prentice-Hall Inc. Englewood Cliffs, New Jersey, Copyright 1959.

composition might be classified as a volatile oil in one reservoir and a gas condensate in a deeper and hotter reservoir. Reservoirs should not be mistakenly classified on the basis of the production characteristics observed at the surface i.e. the yield of hydrocarbon liquid per mmcf of gas. If the reservoir temperature lies between the critical temperature and the cricondentherm of the reservoir fluid, the reservoir is classified as a retrograde gas-condensate reservoir. If the initial reservoir pressure is above the dew point pressure, the hydrocarbon system exists as a single phase (vapor) in the reservoir. As the reservoir pressure declines isothermally (constant temperature) because of production depletion to the dew point pressure or "saturation" pressure, liquids begin to condense out of the gas into the formation. As the pressure is further decreased, instead of expanding (if a gas) or vaporizing (if a liquid) as would be expected, the hydrocarbon mixture tends to condense even more. The retrograde condensation process continues with decreasing pressure until the liquid drop-out reaches its maximum. At this point, some of the liquid which formed in the reservoir may vaporize or near wellbore condensate banking occurs.²

The heptanes plus (C_7+) composition in the wells is 6.365 Mole%. Subsequent research indicates there is a sharp dividing line between oils and condensates from a compositional basis. Reservoirs containing in excess of 12.5 Mole% C_7+ components are almost always in the liquid phase (hence oils). Those with less than 12.5 Mole% are almost always in the gas phase in the reservoir. Oils have been observed with heptanes and heavier concentrations as low as 10% and condensates as high as 15%, but these cases are very rare and exhibit very high tank liquid gravities.³ A research study on hundreds of wells that were properly conditioned and tested, tracked the C_7+ Mole% versus PVT analysis of each well for the determination of dew point or bubble point. The analysis determined that wells with over 12.5 Mole% C_7+ had measured bubble points (oil well) and wells with less than 12.5 Mole% C_7+ had measured dew points (gas wells).⁴

The liquid hydrocarbons produced at the surface have "flashed" at the surface separation equipment and do not meet the statutory definition of *crude petroleum oil*. The hydrocarbon "liquid" that exists in a retrograde gas condensate reservoir will be the result of *gas condensation*. In a retrograde gas condensate reservoir, the condensed liquids should not be considered in determining the gas-oil ratio because the liquids produced at the surface. The flash condensate at the surface is caused by the pressure/temperature reduction. There is no substantiating data that crude petroleum oil is being produced at the surface.

The examiner recommends the application be approved and the well should be classified as a gas well. The subject well meets the following guide lines:

² If the reservoir temperature is near the critical temperature, when the dew point pressure is reached, there will be a rapid liquid build-up (condensation) and subsequently a dramatic increase in the GOR. It should be noted that the composition and mol percent of the hydrocarbons in the reservoir changes significantly with depleting reservoir pressure.

³ Engineering Applications of Phase Behavior of Crude Oil and Condensate Systems, by Phillip L. Moses, SPE, Core Laboratories, Inc., copyright 1986 Society of Petroleum Engineers, published in the *Journal of Petroleum Technology*, July 1986.

⁴ Research by William McCain, Phd, Professor at Texas A&M University.

- * There is a measured dew point (saturation) pressure and subsequent pressure reduction result in the condensing of liquid hydrocarbon as shown by a PVT analysis.
- * The Mole percentage of heptanes plus is $\leq 12.5\%$.
- * The maximum percentage of hydrocarbon liquid occupies only 6.63% of the HCPV.
- * The reservoir is above the critical temperature (this temperature does not necessarily have to be measured if there is a clear demonstration that condensate forms and increases with pressure reductions below the dew point).

FINDINGS OF FACT

1. Notice of this hearing was sent to all affected persons in the subject area field at least ten (10) days prior to the subject hearing.
2. There was no protest at the call of the hearing.
3. The Bouldin Lake (Lower Frio) Field was discovered by completion of the Brigham Oil & Gas, Wyse Lease Well No. 1 through 3 sets of perforations from 14,111' to 14,175' subsurface depth on April 16, 2005.
4. The entire combined correlative interval from 13,903' to 14,175' as shown on the Type Log of the Brigham Oil & Gas, Wyse Lease Well No. 1 (API No. 321-32040), C.R. Bostwick & R. Brotherton Survey, A-6, Matagorda County, Texas should be designated as the Bouldin Lake (Lower Frio) Field.
 - a. A review made of all wells within the 2.5 miles of the discovery well indicates that the closest comparable production from same correlative Frio Sand is the Rugeley, SW. (12850) Field.
 - b. The well in the Rugeley, SW. (12850) is perforated from 12,851' to 12,911' and cross-section well log analysis indicates that there is a major fault separation with over 1,000' of throw displacement.
5. Because the proposed new field is combining multiple productive zones, a two-factor allocation formula is necessary for the protection of correlative rights pursuant to State Statutes. The proposed two-factor allocation formula based on 75% deliverability and 25% per well satisfies this requirement.
6. The Brigham Oil & Gas (now Penn Virginia Oil & Gas), Wyse Lease Well No. 1 in the Bouldin Lake (Lower Frio) Field should be permanently designated as a gas well. The well tested at 3,556 MCFD on a 10/64th choke flowing at 7,496 psig. The initial gas/liquid ratio

- was 7,802:1. The original static reservoir conditions reported was 11,739 psig and 297°F.
- a. The gas gravity is 0.710 and the condensate gravity is 48° API (color is amber).
 - b. Cumulative production through February 2006 is 77.5 MMCF of gas and 7,942 barrels of condensate. The current GOR is 7,388. The current producing rate is 120 MCFD and 11 BC/D.
7. The Brigham Oil & Gas (now Penn Virginia Oil & Gas), Wyse Lease Well No. 1 in the Bouldin Lake (Lower Frio) Field should be permanently designated as a gas well
- a. The original static reservoir pressure was 11,739 psia at 297°F.
 - b. The mechanical Constant Composition Expansion (CCE) results show a measured dew point pressure of 5,684 psig at 297°F.
 - c. The reservoir fluid did exist as a single-phase system at initial reservoir conditions.
 - d. Any hydrocarbon liquids that condense from the gas phase in the formation are immobile.
 - e. Compositional analysis indicates the wellstream to be 71.16 Mole% methane and 6.365 Mole% heptanes plus.
 - f. The CCE analysis measured the maximum hydrocarbon liquid volume in the two-phase envelope will occupy 6.63% of the hydrocarbon pore volume (HCPV) at 2,223 psig.
 - g. The reservoir is above the critical temperature as demonstrated by gas-condensation through reservoir pressure reduction at constant temperature.
8. Cancellation of any overproduction will not harm correlative rights as this is the only well in the subject field.

CONCLUSIONS OF LAW

1. Proper notice was given to all parties as set out in the provisions of all applicable codes and regulatory statutes.
2. All things have occurred and been accomplished to give the Commission jurisdiction in this matter.
3. Adoption of the proposed new field designation and field rule will prevent waste, foster

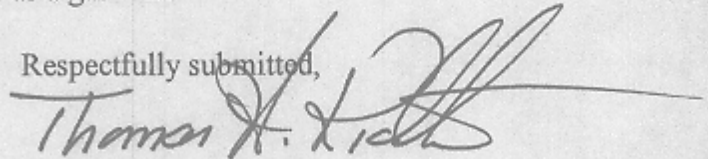
conservation and protect correlative rights.

4. The Brigham Oil & Gas (now Penn Virginia Oil & Gas), Wyse Lease Well No. 1 in the Bouldin Lake (Lower Frio) Field meets the requirements for gas well classification pursuant to Statewide Rule No. 79(a)(11)(C).

EXAMINER'S RECOMMENDATION

Based on the above findings and conclusions of law, the examiner recommends the proposed new field designation and field rule for the Bouldin Lake (Lower Frio) Field be adopted. Further, the Brigham Oil & Gas (now Penn Virginia Oil & Gas), Wyse Lease Well No. 1 in the Bouldin Lake (Lower Frio) Field should be permanently classified as a gas well.

Respectfully submitted,



Thomas H. Richter, P.E.
Technical Examiner
Office of General Counsel