

**ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY**

FIELD/POOL
PIERSON
S. PIERSON UNIT #1
PVT ANALYSIS

Prepared For

Anderson Exploration Ltd.

Prepared By

Hycal Energy Research Laboratories Ltd.

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SUMMARY

SUMMARY

At the request of Anderson Exploration Ltd., Hycal Energy Research Laboratories Ltd. conducted a reservoir fluid study on recombined separator fluid samples collected from the Pierson Field, Well 7-17-2-29 W1M. The experimental work was completed at the reservoir temperature of 42°C. The salient conclusions and recommendations for this study are:

1. On the basis of a detailed compositional analysis, recombination, constant composition expansion and differential liberation, sufficient data have been provided to effectively characterize the fluid properties of the Pierson Field Well 7-17-2-29 W1M.
2. The live oil exhibited behavior typical of a medium gravity (28° API) oil system. There was no evidence of asphaltene or wax precipitation in any of the tests, nor of any other unusual phenomena during the course of this study.
3. The live oil used in this study had the following properties:

Saturation (i.e. bubblepoint) Pressure 3300 kPag.

Compressibilities

From 23442 to	20684 kPag	$[0.7649 \times 10^{-6} \text{ kPa}^{-1}]$
From 20684 to	17237 kPag	$[0.7790 \times 10^{-6} \text{ kPa}^{-1}]$
From 17237 to	13789 kPag	$[0.8019 \times 10^{-6} \text{ kPa}^{-1}]$
From 13789 to	10342 kPag	$[0.8380 \times 10^{-6} \text{ kPa}^{-1}]$
From 10342 to	6895 kPag	$[0.8739 \times 10^{-6} \text{ kPa}^{-1}]$
From 6895 to	4137 kPag	$[0.9859 \times 10^{-6} \text{ kPa}^{-1}]$

4. The differentially liberated live oil had the following properties at reservoir temperature:

Live Oil Density at Saturation Pressure (kg/m ³)	828.1
Depleted Residual Oil Density at Ambient Pressure (kg/m ³)	866.7
Live Oil Viscosity at Saturation Pressure (mPa•s)	2.274
Depleted Residual Oil Viscosity at Ambient Pressure (mPa•s)	5.740

Live Oil Solution Gas-Oil Ratio at Saturation Pressure (m^3/m^3)	27.75
Live Oil Formation Volume Factor at Saturation Pressure (Rm^3/STm^3)	1.1135

5. Hycal recommends use of results herein for volumetric and material balance calculations as well as for input to reservoir simulation, as desired by Anderson Exploration.

DISCUSSION

RESULTS AND DISCUSSION

On December 22, 1999, separator oil and gas samples were collected from the Pierson Field, Well 7-17-2-29 W1M. The sample collection data are provided in Table 1. The separator oil and gas underwent compositional analysis, the results of which are given in Tables 2 and 3. Separator oil and gas samples were recombined targeting the producing GOR of $38 \text{ m}^3/\text{m}^3$. This resulted in a recombination with a bubble point pressure of 6123 kPag at 42°C . As reservoir pressure was 3300 kPag, the recombination was not physical. Given this, Hycal used its Separator Wizard technology to generate a "true" solution gas composition. The Separator Wizard uses as its basis an equation of state (EOS) model tuned to the results of the laboratory recombination. Once tuned, the EOS was used to determine the amount of excess gas production (a free gas that was produced along with the solution gas from the insitu oil) and what the true solution gas composition was, so that the live oil would have a bubble point pressure equal to reservoir pressure. Once the gas composition had been established, it was blended from pure components and recombined with the field sampled separator oil. After recombination, the sample was analyzed. The live oil underwent a pressure-volume experiment to establish that the sample had a saturation pressure of 3300 kPag at the reservoir temperature of 42°C . From a single stage flash of a portion of the sample, the GOR was determined to be $25.5 \text{ m}^3/\text{m}^3$ and the B_o to be $1.096 \text{ Rm}^3/\text{STm}^3$. Compositional analysis was performed on the oil and is provided in Table 4.

The test cylinder was then charged with a portion of the live oil sample and a constant composition expansion experiment (CCE) was performed on the oil, as described in the "Procedures and Equipment" section of this report. Table 5 provides the results of the average compressibility of the reservoir fluid at pressures above the bubblepoint. Table 6 contains the remainder of the results from the CCE. The relative total volume (V/V_{sat}) data have been plotted on Cartesian coordinates and appear in Figure 1. The discontinuity on this curve indicates the saturation pressure of the reservoir fluid. At pressures above the saturation pressure the fluid is relatively incompressible, resulting in the shallow slope of the relative volume curve and its generally linear

behaviour. Below the bubblepoint the system exists in two phases. Thus large volume changes are required to induce any significant pressure changes. This effect becomes more pronounced the farther the pressure is below the saturation pressure as signified by the vertically asymptoting portion of the relative volume curve. When applied to material balance calculations, the Y-Function is often used to smooth oil formation volume factors, as described in Craft and Hawkins⁷. In this method, the Y-Function can be defined as a linear function of pressure; then, given a set of experimentally determined relative oil volumes, the Y-Function can be used to back-fit the relative volume data to produce "smooth" data for later simulation work. As well, linearity of the Y-Function, as shown in Figure 1, indicates consistency of the experimental results.

Table 7 contains various property measurements made on the differentially liberated oil below the bubblepoint including live oil density, oil formation volume factor and gas-oil ratios. The increase in oil density below the bubblepoint (where it displays an absolute minimum) is due to the evolution and removal of gas, achieving a local maximum at ambient pressure (Figure 2). The formation volume factor (shown as relative oil volume) displays an inverse functionality as oil density: it reaches its maximum value at the bubblepoint pressure, decreasing at pressures above and below the bubblepoint, as seen in Figure 3. The decrease in formation volume factor at pressures greater than the bubblepoint is due to the compressibility of the oil. The decrease at pressures less than the bubblepoint is due to the evolution and removal of solution gas. Figure 4 depicts the liberated and solution gas-oil ratios measured throughout the experiment. Table 8 contains a summary of the properties of the differentially liberated gas including gas gravities, deviation factors, gas formation volume factors and gas expansion factors. The gas deviation factor (Z), gas formation volume factor and gas expansion factor, and gas gravity are shown in Figures 5 through 7, respectively.

Table 9 provides the results of the reservoir fluid viscosity measurements. These data are shown graphically in Figures 8 and 9. Oil viscosity displays an absolute minimum value at the bubblepoint and increases subtly as pressure increases above the bubblepoint due to fluid compression effects. Oil viscosity increases dramatically below the bubblepoint as pressure is

reduced due to the evolution and removal of solution gas from the system. Gas phase viscosity was calculated using the compositional data and the Lee, Gonzalez, Eakin correlation¹. Gas properties were calculated using methods outlined in References 2 through 5.

Table 10 summarizes the effluent gas compositions from each pressure stage during the differential liberation experiment. Figures 10 and 11 show a portion of this data plotted on semi-log coordinates. Table 11 is a compositional analysis of the residual oil remaining after completion of the experiment.

Appendix A shows a material balance check performed on this experiment. It is shown in terms of formation volume factor such that the balance can be checked on a point by point basis rather than solely on an overall basis.

PVT Data Adjustment

The differential liberation experiment models the behavior of the oil insitu. However, as the ultimate fluid volumes (gas and oil) are necessarily constrained by passing through surface equipment, it is necessary to modify the PVT data through other flash data. Typically, a separator flash is performed to define the gas-oil ratio and oil shrinkage (B_o) as a function of surface separation. In this case, the surface separation facilities are near stock tank conditions so the atmospheric flash data acquired during recombination should be sufficient. Table 12 summarizes the PVT data and that same data adjusted as per the atmospheric flash. Figure 12 plots formation volume factor while Figure 13 shows gas-oil ratio.

**PROCEDURES &
EQUIPMENT**

PROCEDURES AND EQUIPMENT

Fluids Preparation and Analysis

Separator oil properties were measured on duplicate samples to verify the quality of the samples. One sample had a single stage flash performed at room temperature while the other was flashed from reservoir temperature. Any significant difference between the two in terms of the GOR could be indicative of a wax problem. Both samples were then subjected to compositional analysis to further compare the samples and also to possibly detect sample contamination by extraneous hydrocarbon fluids.

Duplicate separator gas samples were analyzed for composition at both room and reservoir temperatures. Any discrepancy between the two analyses may indicate that some components in the samples have condensed to liquid and that the samples must be heated before use to vaporize these components.

To recombine live oil from separator oil and separator gas, the gas was first condensed into a high pressure cylinder for high pressure applications. By immersing the target high pressure cylinder in liquid nitrogen the low pressure gas could be readily transferred. The amount of pressure drop (ΔP in dimensionless atmospheres) is calculated in terms of the amount of live oil (V_{oil}) needed, the GOR of the oil, the live oil formation volume factor (B_o), and the volume of the gas tank (V_{tank}).

$$\Delta P = \frac{V_{oil} (cc) \times GOR (cc/cc)}{B_{oil} \times V_{tank} (cc)}$$

Once the specified pressure drop had been achieved on the source gas in the low pressure tank, the high pressure cylinder was then heated to system temperature. To increase the pressure to operating pressure mercury was injected into the bottom of the cylinder which acted as a confining fluid. In this manner any pressure can be obtained (up to 70 MPa) and a constant pressure injection can be maintained. A schematic of this equipment is illustrated in Figure 14.

Secondly, the oil supplied was from a separator sample. The required value of the separator sample (V_{sep}) was calculated and added to the target cylinder. The live separator oil was pressured above the sampling pressure to ensure a single phase fluid when transferring.

$$V_{sep} = \frac{V_{oil} \times B_{sep}}{B_{oil}} (cc)$$

Once the gas and oil were added together, the cylinder was isolated and thoroughly agitated at reservoir temperature to ensure a homogeneous fluid system.

The recombined sample was then subjected to a constant composition experiment (CCE) to determine the saturation pressure. The fluid system was then pressurized to well above the bubblepoint and mixed into single phase. A single stage flash gas-oil ratio (GOR) was measured by flashing a sample of the fluid from some pressure greater than the bubblepoint at reservoir temperature into an atmospheric separator and measuring the corresponding volumes of gas and liquid. This flash also provided parameters such as formation volume factor (B_o) and live oil density. Although these values are measured relative to the single phase fluid pressure from which they were flashed, the CCE provides data allowing these values to be corrected to the bubblepoint. These fluids (gas and liquid) were then subjected to compositional analysis using GC analysis as mentioned in the "Description of Equipment for Compositional Analysis" from which a computer-generated live oil composition can be determined. Compositions of these gases and oils are determined in the following manner.

Mole fractions of gases are determined by injecting the gas of interest to an evacuated sample system, but maintaining a slight negative pressure (7 cm Hg vacuum). The carrier gas (helium) transports the gas into the column; the thermal conductivity detector (TCD), flame ionizing detector (FID), and integrator indicate an area associated with each component. These areas are then translated into component mole fractions by the following formula:

$$\text{Mole Fraction}_{(i)} = \frac{\text{Area}_{(i)} \times \text{Calibration Constant}_{(i)}}{\sum_{i=1}^{N_{\text{total}}} \text{Area}_{(i)} \times \text{Calibration Constant}_{(i)}}$$

The subscript *i* in the expression represents the *i*th component in the gas and the calibration constant is an empirical amount per area ratio which relates the area detected to the mole fraction that should be present in the analytical standard. If the resulting mole fractions deviate from the standard, new calibration constants are calculated knowing the mole fraction and the area detected. Thus recalibration is easy to perform and can be checked daily by running a standard sample. Recalibration is usually only necessary biweekly at most and often only monthly. When recalibrated, the differences are very slight and often affect the non-hydrocarbons only.

Mole fractions in the flashed liquid sample are determined by injecting the liquid sample into the megabore column of the HP5890 GC. Calibration is made on a component basis. However, there are many more components than with the gas: a total of 47 hydrocarbon components including the unsaturated cyclics and aromatics enumerated in the "Description of Equipment for Compositional Analysis". Calibration of this column is carried out using a quantitative standard containing C₆ through C₄₀. The main deficiency of this analytical method is related to the fraction that does not elute from the column.

Some components, especially the heavier end of an oil sample, leave some residual amount behind in the column. This non-eluted portion, if uncorrected, will indicate a smaller fraction of these components than is actually present. In order to account for any hydrocarbon that is not eluted at the final temperature, the oil analyses are corrected based on a stabilized molecular weight (C₆₊) measured by cryoscope and a "non-elution" trial. The non-elution trial uses a GC run identical to the original oil analysis except that the liquid sample has had a measured quantity of 1-hexene added. The 1-hexene is designed to completely, or nearly completely, elute the oil sample in the GC column. Also, 1-hexene is used as the elution agent because it does not normally appear naturally

in reservoir fluids, thus allowing for its quick and easy identification amongst the naturally occurring oil components. After the 1-hexene eluted duplicate run has been performed the amount of original oil sample not eluted can be determined. Thus the fraction of the oil not eluted can be quantified and a correction applied to the compositional analysis. This appears in the form of a C_{30+} correction. Not only does this factor correct for the fraction of C_{30+} in the oil sample but it also accounts for the fraction not eluted amongst any of the components lighter than C_{30+} .

From previous studies, Hycal Energy Research Laboratories Ltd. has found that using a common C_{30+} mass fraction and molecular weight correction is adequate for the majority of compositions of the same oil. For those few compositions that have undergone considerable mass transfer, this correction may be insufficient, but the error is attenuated since the corresponding gas analysis is unaffected and the GOR's for these samples are usually high.

Differential Liberation Experiment

Following the determination of the properties of the live oil used for the study, the sample was divided into two portions of approximately 150 cc and 350 cc. The first portion was used for the volumetric portion of the differential liberation while the second portion was used for the measurement of viscosity.

The first oil portion was transferred at some pressure greater than saturation pressure, to ensure single phase, into a 300 cc high pressure 316 SS cylinder, rated to 70 MPa at reservoir temperature. It is within this cylinder that the volumetric portion of the differential liberation was performed. The actual differential liberation experiment consists of two parts: the constant composition expansion (CCE) and the differential liberation.

The CCE was performed on the oil primarily, as stated in "Fluids Preparation and Analysis", to determine the bubblepoint of the oil, but does provide additional information. The CCE was performed by reducing the pressure from some point above the bubblepoint incrementally, allowing for equilibrium at each pressure stage. This was performed until the pressure was well below the

bubblepoint. This allows for the determination of live oil compressibility above the bubblepoint and relative oil volume over the entire pressure range. Subsequent to the CCE, the oil was returned to single phase by pressuring it to well above the bubblepoint and agitating it to ensure proper mixing. Once this was complete, the differential liberation experiment was ready to begin.

A differential liberation experiment was performed by reducing the pressure in the 300 cc test cylinder in stages and analyzing the evolved gas phase and the remaining live oil volume. A typical pressure stage was performed as follows:

1. The pressure in the sample cylinder was reduced to a pressure just above the bubblepoint of the oil.
2. This was the starting point for the differential liberation. From here the pressure was reduced in the cylinder to the first designated pressure stage and time was allowed for the system to equilibrate.
3. At constant pressure, the evolved gas phase was removed from the test cylinder and flashed through a test separator. By flashing through a separator any condensate which may drop out from the gas can be collected. GC analysis is performed on the evolved gas and any liquids collected.
4. Steps 2 and 3 were repeated until either atmospheric pressure or a designated pressure is reached (i.e. a predicted reservoir abandonment pressure).

This procedure is also outlined graphically in Figure 15. The oil is initially at pressure P_i , some pressure above the bubblepoint and exists in a single phase. The pressure is then reduced to the bubblepoint at constant temperature. This corresponds to moving from point P_i on the graph straight down to the edge of the phase envelope. The pressure is then further reduced to some pressure, P_1 . The live oil then evolves gas and becomes a two phase system. After the system has had sufficient time to equilibrate, the evolved gas phase is removed from the system by pushing it out the top of the test cell at constant pressure, P_1 . After all the gas has been removed the pressure is again reduced, this time to pressure P_2 . Again, after equilibration, the gas phase is removed. This is repeated until atmospheric or abandonment pressure is reached, denoted on the graph as P_a .

The second portion of the live oil sample was then transferred in single phase to a 500 cc 316 SS high pressure cylinder rated to 70 MPa. The identical steps as shown above were repeated. The larger volume provides sufficient fluid such that viscosity and density measurements may be made at each equilibrium stage while ensuring sufficient live oil remains for subsequent pressure stages.

Description of Equipment for Compositional Analysis

The analyses of the liquids and gases used in this experiment were carried out on gas chromatographs (GC). Various techniques can be used to perform compositional analyses on hydrocarbon gases and liquids.

Analyses of light hydrocarbon fluids are conducted using an HP5890 liquid injection gas chromatograph equipped with flame ionization detector (FID) operated to maximum temperature of 300°C. Separation of individual components is performed with a 30 metre, 530 micrometre diameter "Megabore" capillary column. It is a fused silica column using methyl silicone as the stationary phase. The stationary phase is 2.6 micrometers thick and is rated for operation in the temperature range of -60 to 300°C. Over this temperature range, the hydrocarbon components eluted are C₁ to C₃₆ along with cyclopentane, methylcyclopentane, cyclohexane, methylcyclohexane, benzene, toluene, ethylbenzene, para- and meta-xylene, ortho-xylene and 1,2,4-trimethylbenzene. That is, each of these components is retarded in its flow through the column, based on its physical properties, by the stationary phase. Thus the sample becomes segregated as it passes through the column. With prior knowledge of the amount of "retention" of a given compound, its relative amount can be determined by the length of time it remains in the column before finally passing through. This is known as its retention time. This can, for some compounds, be lengthy so typically the temperature is gradually increased during the analysis to shorten retention times by a predefined amount.

The gas analyses are carried out on an HP5890 gas injection GC equipped with two separation columns. The first column is a combination of a 100 mesh packed column and a 100 mesh molecular sieve using high purity helium as a carrier gas. The molecular sieve is used to

achieve separation of the very light gaseous components (N_2 , O_2 , C_1) while the packed column serves to separate ethane, propane, butanes, pentanes and hexanes plus along with CO_2 and H_2S . The second column is a capillary column as described above. This column is capable of achieving separation of components up to C_{12+} , along with the associated naphthenes and aromatics, although these values are typically lumped into the C_{6+} fraction during analysis. Components up to C_4 are analyzed using a thermal conductivity detector (TCD) while the C_{5+} components are analyzed using an FID. The instrument has programmable air-actuated multiport valves that allow the flow of the sample mixture to be varied between the two columns, providing for the correct separation and analysis of the injected sample gas.

Differential Liberation Apparatus

The equipment used for this experiment consists of a 300 cc 316 SS test cylinder, source cylinder, capillary tube, oven, buffers and pumps, as shown in Figure 16. The 300 cc test cylinder is the heart of the apparatus where the fluids of interest are injected. The cylinder has a pressure rating of 70 MPa at $150^\circ C$. Connected to the receiver cylinder via small bore stainless steel tubing is a high pressure source cylinder containing the reservoir fluid. Displacing mercury into the bottom of the source cylinder transfers a corresponding volume into the test cylinder. Thus fluids can be transferred in prescribed volumes to within about 0.02 cc. The source cylinder is typically a 600 cc 316 SS high pressure cylinder rated to 70 MPa.

The capillary tube is used for measuring viscosity of the reservoir fluid at pressures above the bubblepoint, near the bubblepoint and at the depletion pressures below the bubblepoint. It is a small diameter tube of precisely known dimensions. A double barrel Ruska pump was connected to either end of the system to facilitate the injection and withdrawal of the test fluid. Pressure differential across the tube is monitored using a Validyne pressure transducer. The transducer measures the direct pressure differential across the capillary tube irrespective of the particular system pressure at the sample point. The transducer output is then directed to a Validyne MCI 20 channel computer control centre which provides a digital readout of the instantaneous pressure differential in the system.

The 300 cc test cylinder, capillary tube and receiver cylinders are mounted within a temperature controlled oven so that desired thermal test conditions can be attained. Temperature is controlled using a CIC temperature controller accurate to $\pm 0.5^{\circ}\text{C}$. An internally mounted thermometer is present to provide an exact reading of the system temperature. Two fans circulate the air mass inside the oven to ensure a uniform temperature distribution throughout the system.

The entire oven apparatus is mounted on a rotating swivel and can be rotated through 180°C by an attached motor and chain drive. This arrangement allows the oil to be well mixed in the test cylinder. The oven can be rotated continuously or on a timed basis. The oven front and back are also equipped with explosion-proof sight glasses to facilitate the observation of the system without opening the oven door and upsetting test thermal conditions.

Data Diskette Summary

A 3½" high density data diskette is included at the end of the report. This diskette contains all pertinent numerical information from the test series summarized in standard spreadsheet format. This will facilitate the plotting and manipulation of the data as required. A summary of the worksheet files contained on the data diskette is as follows:

File Name*	Contents
99143T02.WK1	Compositional Analysis of Separator Oil
99143T03.WK1	Compositional Analysis of Separator Gas
99143T04.WK1	Compositional Analysis of Reservoir Fluid
99143T05.WK1	Average Live Oil Compressibilities
99143T06.WK1	Constant Composition Expansion
99143T07.WK1	Differential Liberation Oil Properties
99143T08.WK1	Differential Liberation Gas Properties
99143T09.WK1	Reservoir Fluid Viscosity Data
99143T10.WK1	Compositional Analysis of Liberated Gas
99143T11.WK1	Compositional Analysis of Residual Oil
99143T12.WK1	PVT Data Adjustment

* These are Lotus 1-2-3 spreadsheets that will open in virtually all client-based versions of Lotus or Excel.

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TABLES

TABLE 1
ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
SAMPLE COLLECTION DATA

Operator Name	Anderson
Well Location	7-17-2-29W1M
Field or Area	Pierson
Sampling Company	Hycal Energy
Name of Sampler	C.C.
Sampling Date	December 22, 1999
Sampling Point	Separator
Sampling Temperature (°C)	8
Sampling Pressure (kPag)	331
Reservoir Temperature (°C)	42
Reservoir Pressure (kPag)	3300

TABLE 2
ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
COMPOSITIONAL ANALYSIS OF SEPARATOR OIL (SAMPLE W3B 5028)

Boiling Point (°C)	Component		Mole Fraction	Mass Fraction	
-195.8	Nitrogen	N ₂	0.0123	0.0016	Calculated Properties of Total Sample
-78.51	Carbon Dioxide	CO ₂	0.0000	0.0000	
-60.31	Hydrogen Sulphide	H ₂ S	0.0000	0.0000	
-161.7	Methane	C ₁	0.0036	0.0003	
-88.9	Ethane	C ₂	0.0172	0.0024	Molecular Weight 214.52
-42.2	Propane	C ₃	0.0296	0.0061	Calculated Properties of C₆₊ Fraction
-11.7	i-Butane	i-C ₄	0.0080	0.0022	
-0.6	n-Butane	n-C ₄	0.0661	0.0179	
27.8	i-Pentane	i-C ₅	0.0347	0.0117	
36.1	n-Pentane	n-C ₅	0.0428	0.0144	C ₆₊ Molecular Weight 257.62
36.1 - 68.9	Hexanes	C ₆	0.0615	0.0247	C ₆₊ Mole Fraction 0.7856
68.9 - 98.3	Heptanes	C ₇	0.0834	0.0389	C ₆₊ Density (g/cc) 0.8960
98.3 - 125.6	Octanes	C ₈	0.0607	0.0323	Calculated Properties of C₇₊ Fraction
125.6 - 150.6	Nonanes	C ₉	0.0469	0.0280	
150.6 - 173.9	Decanes	C ₁₀	0.0527	0.0350	
173.9 - 196.1	Undecanes	C ₁₁	0.0452	0.0310	
196.1 - 215.0	Dodecanes	C ₁₂	0.0383	0.0287	C ₇₊ Molecular Weight 273.43
215.0 - 235.0	Tridecanes	C ₁₃	0.0435	0.0355	
235.0 - 252.2	Tetradecanes	C ₁₄	0.0301	0.0267	
252.2 - 270.6	Pentadecanes	C ₁₅	0.0259	0.0249	
270.6 - 287.8	Hexadecanes	C ₁₆	0.0233	0.0241	C ₇₊ Mole Fraction 0.7197
287.8 - 302.8	Heptadecanes	C ₁₇	0.0197	0.0218	C ₇₊ Density (g/cc) 0.9037
302.8 - 317.2	Octadecanes	C ₁₈	0.0199	0.0233	
317.2 - 330.0	Nonadecanes	C ₁₉	0.0177	0.0217	
330.0 - 344.4	Eicosanes	C ₂₀	0.0155	0.0198	
344.4 - 357.2	Heneicosanes	C ₂₁	0.0125	0.0169	
357.2 - 369.4	Docosanes	C ₂₂	0.0124	0.0176	
369.4 - 380.0	Tricosanes	C ₂₃	0.0102	0.0151	
380.4 - 391.1	Tetracosanes	C ₂₄	0.0090	0.0139	
391.1 - 401.7	Pentacosanes	C ₂₅	0.0086	0.0139	
401.7 - 412.2	Hexacosanes	C ₂₆	0.0068	0.0113	
412.2 - 422.2	Heptacosanes	C ₂₇	0.0071	0.0123	
422.2 - 431.7	Octacosanes	C ₂₈	0.0066	0.0119	
431.7 - 441.1	Nonacosanes	C ₂₉	0.0057	0.0108	
Above 441.1	Tricontanes Plus	C ₃₀₊	0.0460	0.3699	
Naphthenes					
48.9	Cyclopentane	C ₅ H ₁₀	0.0045	0.0015	
72.2	Methylcyclopentane	C ₆ H ₁₂	0.0179	0.0070	
81.1	Cyclohexane	C ₆ H ₁₂	0.0171	0.0067	
101.1	Methylcyclohexane	C ₇ H ₁₄	0.0080	0.0037	
Aromatics					
80	Benzene	C ₆ H ₆	0.0030	0.0011	
110.6	Toluene	C ₇ H ₈	0.0028	0.0012	
136.1 - 138.9	Ethylbenzene, p&m-Xylene	C ₈ H ₁₀	0.0046	0.0023	
144.4	o-Xylene	C ₈ H ₁₀	0.0078	0.0039	
168.9	1,2,4-Trimethylbenzene	C ₉ H ₁₂	0.0110	0.0061	
Total			1.0000	1.0000	

TABLE 3
ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
COMPOSITIONAL ANALYSIS OF SEPARATOR GAS (SAMPLE 71)

Component	Mole Fraction As Analyzed	Mole Fraction Acid Gas Free	Liquid Vol. (mL/m ³)
N ₂	0.1900	0.1900	
CO ₂	0.0000	0.0000	
H ₂ S	0.0000	0.0000	
C ₁	0.5437	0.5437	
C ₂	0.1305	0.1305	
C ₃	0.0950	0.0950	348.47
i-C ₄	0.0102	0.0102	44.54
n-C ₄	0.0224	0.0224	94.14
i-C ₅	0.0035	0.0035	17.13
n-C ₅	0.0033	0.0033	15.88
C ₆₊	0.0013	0.0013	6.59
Total	1.0000	1.0000	526.74
Calculated Total Sample Properties			
Molecular Mass	24.67	Net Heating Value (MJ/m ³)	39.368
Gas Gravity	0.8517	Gross Heating Value Wet (MJ/m ³)	42.506
		Gross Heating Value Dry (MJ/m ³)	43.259
Ppc (kPa)	4333.39	Ppc* (kPa)	4333.07
Tpc (K)	220.16	Tpc* (K)	220.14
* Corrected for acid gas content			

TABLE 4
ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
COMPOSITIONAL ANALYSIS OF RESERVOIR FLUID

Boiling Point (°C)	Component		Mole Fraction	Mass Fraction	
-195.8	Nitrogen	N ₂	0.0031	0.0005	Calculated Properties of Total Sample
-78.51	Carbon Dioxide	CO ₂	0.0000	0.0000	
-60.31	Hydrogen Sulphide	H ₂ S	0.0000	0.0000	
-161.7	Methane	C ₁	0.1164	0.0103	Molecular Weight 181.15
-88.9	Ethane	C ₂	0.0580	0.0096	
-42.2	Propane	C ₃	0.0449	0.0109	Calculated Properties of C₆₊ Fraction
-11.7	i-Butane	i-C ₄	0.0101	0.0032	
-0.6	n-Butane	n-C ₄	0.0622	0.0200	
27.8	i-Pentane	i-C ₅	0.0293	0.0117	C ₆₊ Molecular Weight 259.77
36.1	n-Pentane	n-C ₅	0.0344	0.0137	
36.1 - 68.9	Hexanes	C ₆	0.0460	0.0219	
68.9 - 98.3	Heptanes	C ₇	0.0777	0.0430	C ₆₊ Mole Fraction 0.6416
98.3 - 125.6	Octanes	C ₈	0.0535	0.0337	C ₆₊ Density (g/cc) 0.8959
125.6 - 150.6	Nonanes	C ₉	0.0412	0.0292	Calculated Properties of C₇₊ Fraction
150.6 - 173.9	Decanes	C ₁₀	0.0414	0.0325	
173.9 - 196.1	Undecanes	C ₁₁	0.0392	0.0318	
196.1 - 215.0	Dodecanes	C ₁₂	0.0330	0.0293	C ₇₊ Molecular Weight 274.34
215.0 - 235.0	Tridecanes	C ₁₃	0.0300	0.0290	
235.0 - 252.2	Tetradecanes	C ₁₄	0.0241	0.0253	
252.2 - 270.6	Pentadecanes	C ₁₅	0.0207	0.0236	C ₇₊ Mole Fraction 0.5923
270.6 - 287.8	Hexadecanes	C ₁₆	0.0181	0.0221	C ₇₊ Density (g/cc) 0.9030
287.8 - 302.8	Heptadecanes	C ₁₇	0.0179	0.0234	
302.8 - 317.2	Octadecanes	C ₁₈	0.0151	0.0209	
317.2 - 330.0	Nonadecanes	C ₁₉	0.0134	0.0194	
330.0 - 344.4	Eicosanes	C ₂₀	0.0119	0.0181	
344.4 - 357.2	Heneicosanes	C ₂₁	0.0108	0.0173	
357.2 - 369.4	Docosanes	C ₂₂	0.0100	0.0169	
369.4 - 380.0	Tricosanes	C ₂₃	0.0091	0.0160	
380.4 - 391.1	Tetracosanes	C ₂₄	0.0081	0.0148	
391.1 - 401.7	Pentacosanes	C ₂₅	0.0074	0.0140	
401.7 - 412.2	Hexacosanes	C ₂₆	0.0071	0.0140	
412.2 - 422.2	Heptacosanes	C ₂₇	0.0062	0.0129	
422.2 - 431.7	Octacosanes	C ₂₈	0.0060	0.0128	
431.7 - 441.1	Nonacosanes	C ₂₉	0.0056	0.0124	
Above 441.1	Tricontanes Plus	C ₃₀₊	0.0377	0.3589	
Naphthenes					
48.9	Cyclopentane	C ₅ H ₁₀	0.0034	0.0013	
72.2	Methylcyclopentane	C ₆ H ₁₂	0.0134	0.0062	
81.1	Cyclohexane	C ₆ H ₁₂	0.0042	0.0019	
101.1	Methylcyclohexane	C ₇ H ₁₄	0.0047	0.0026	
Aromatics					
80	Benzene	C ₆ H ₆	0.0006	0.0003	
110.6	Toluene	C ₇ H ₈	0.0023	0.0012	
136.1 - 138.9	Ethylbenzene, p&m-Xylene	C ₈ H ₁₀	0.0114	0.0067	
144.4	o-Xylene	C ₈ H ₁₀	0.0042	0.0025	
168.9	1,2,4-Trimethylbenzene	C ₉ H ₁₂	0.0063	0.0042	
Total			1.0000	1.0000	

TABLE 5
ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
AVERAGE LIVE OIL COMPRESSIBILITIES

Pressure Range (psig)		Average Oil Compressibility [V/V/psi (x 10 ⁻⁶)]
From	To	
3400	3000	5.2737
3000	2500	5.3709
2500	2000	5.5289
2000	1500	5.7782
1500	1000	6.0252
1000	600	6.7978
Pressure Range (kPag)		Average Oil Compressibility [V/V/kPa (x 10 ⁻⁶)]
From	To	
23442	20684	0.7649
20684	17237	0.7790
17237	13789	0.8019
13789	10342	0.8380
10342	6895	0.8739
6895	4137	0.9859

TABLE 6
ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
CONSTANT COMPOSITION EXPANSION

Pressure		Relative Volume (1)	Y Function (2)	Oil Density (g/cm ³)
(psig)	(kPag)			
3400	23442	0.9831		0.8423
3000	20684	0.9852		0.8405
2500	17237	0.9878		0.8383
2000	13790	0.9906		0.8359
1500	10342	0.9935		0.8335
1000	6895	0.9965		0.8310
600	4137	0.9992		0.8288
479	3303	1.0000		0.8281
460	3172	1.0032	12.6267	
441	3041	1.0070	12.0399	
430	2965	1.0095	11.7002	
422	2910	1.0114	11.4532	
411	2834	1.0144	11.1135	
406	2799	1.0159	10.9591	
348	2399	1.0396	9.1679	
270	1862	1.1093	6.7591	
201	1386	1.2807	4.6282	
164	1131	1.5106	3.4856	
140	965	1.8073	2.7444	
126	869	2.0984	2.3121	
114	786	2.4803	1.9415	
104	717	2.9631	1.6327	
94	648	3.7179	1.3239	
(1) Volume at indicated pressure per volume at saturation pressure				
(2) $Y \text{ Function} = (P_{\text{sat}} - P) / P_{\text{abs}} / (\text{Relative Volume} - 1)$				

TABLE 7
ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
DIFFERENTIAL LIBERATION OIL PROPERTIES @ 42°C

Gauge Pressure		Oil Density (g/cm ³)	Oil Formation Volume Factor (Bo) [1]	Total Formation Volume Factor (Bt) [2]	GOR (m ³ /m ³)	
(psig)	(kPag)				Solution (3)	Liberated (4)
1500	10342	0.8335	1.1062	1.1062	27.75	0.00
479	3300	0.8281	1.1135	1.1135	27.75	0.00
400	2758	0.8304	1.1077	1.2016	25.16	2.58
300	2068	0.8332	1.1001	1.4042	21.49	6.26
200	1379	0.8366	1.0929	1.7268	18.98	8.76
100	689	0.8403	1.0815	3.0419	13.56	14.19
50	345	0.8443	1.0720	5.4646	10.18	17.57
0	0	0.8667	1.0231	35.7255	0.00	27.75
Density of residual oil is 0.887 g/cm ³ @ 15.5°C API gravity of residual oil = 28.0°						
(1) Cubic meters of oil at indicated pressure and temperature per cubic meter of residual oil at 15.5°C (2) Total cubic meters of oil and liberated gas at the indicated pressure and temperature per cubic meter of residual oil at 15.5°C (3) Cubic meters of solution gas at standard conditions per cubic meter of residual oil at 15.5°C (4) Cubic meters of liberated gas at standard conditions per cubic meter of residual oil at 15.5°C						

TABLE 8
ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
DIFFERENTIAL LIBERATION GAS PROPERTIES @ 42°C

Gauge Pressure		Gas Gravity		Gas Deviation Factor (Z)	Gas Formation Vol. Factor Bg [3]	Gas Expansion Factor [4]
(psig)	(kPag)	[1]	[2]			
1500	10342					
479	3300					
400	2758	0.7124	0.7124	0.9350	0.0363	27.527
300	2068	0.7153	0.7141	0.9480	0.0486	20.574
200	1379	0.7500	0.7243	0.9598	0.0723	13.824
100	689	0.8493	0.7720	0.9715	0.1382	7.238
50	345	1.0000	0.8158	0.9778	0.2500	3.999
0	0	1.4081	1.0324	0.9954	1.2507	0.800
* Test conducted at 666.09 mm Hg barometric pressure						
[1] Incremental gas gravity						
[2] Cumulative gas gravity						
[3] Cubic meters of gas at indicated pressure and temperature per cubic meter at standard conditions.						
[4] Cubic meters of gas at standard conditions per cubic meter at indicated pressure and temperature.						

TABLE 9
ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
RESERVOIR FLUID VISCOSITY DATA @ 42°C

Pressure		Oil Viscosity (mPa•s)	Gas Viscosity (mPa•s)	Oil-Gas Viscosity Ratio
(psig)	(kPag)			
1000	6895	2.476		
800	5516	2.393		
600	4137	2.325		
479	3300	2.274		
400	2758	2.536	0.01183	214.40
300	2068	2.835	0.01166	243.04
200	1379	3.230	0.01138	283.72
100	689	3.759	0.01085	346.30
50	345	4.055	0.01023	396.45
0	0	5.740	0.00892	643.77

TABLE 10
ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
COMPOSITIONAL ANALYSIS OF LIBERATED GAS

Component	Differential Liberation Stage Pressure (kPag)					
	2758	2068	1379	689	345	0
N ₂	0.0537	0.0372	0.0232	0.0059	0.0024	0.0005
CO ₂	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H ₂ S	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
C ₁	0.7814	0.7754	0.7367	0.6242	0.4876	0.1613
C ₂	0.0939	0.1118	0.1418	0.2079	0.2324	0.2557
C ₃	0.0391	0.0466	0.0617	0.1034	0.1715	0.3041
i-C ₄	0.0057	0.0059	0.0077	0.0130	0.0231	0.0564
n-C ₄	0.0145	0.0153	0.0196	0.0323	0.0593	0.1606
i-C ₅	0.0047	0.0033	0.0043	0.0062	0.0115	0.0307
n-C ₅	0.0046	0.0032	0.0038	0.0059	0.0105	0.0278
C ₆₊	0.0023	0.0014	0.0011	0.0012	0.0017	0.0029
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
MW	20.63	20.72	21.72	24.60	28.96	40.79
Gravity	0.7124	0.7153	0.7500	0.8493	1.0000	1.4081
Ppc (kPa)	4519.31	4545.57	4558.61	4562.53	4504.87	4306.08
Tpc (K)	212.85	216.47	225.28	246.72	273.36	341.33
Ppc* (kPa)	4519.31	4545.57	4558.61	4562.53	4504.87	4306.08
Tpc* (K)	212.85	216.47	225.28	246.72	273.36	341.33
* Corrected for acid gas content						

TABLE 11
ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
COMPOSITIONAL ANALYSIS OF RESIDUAL OIL

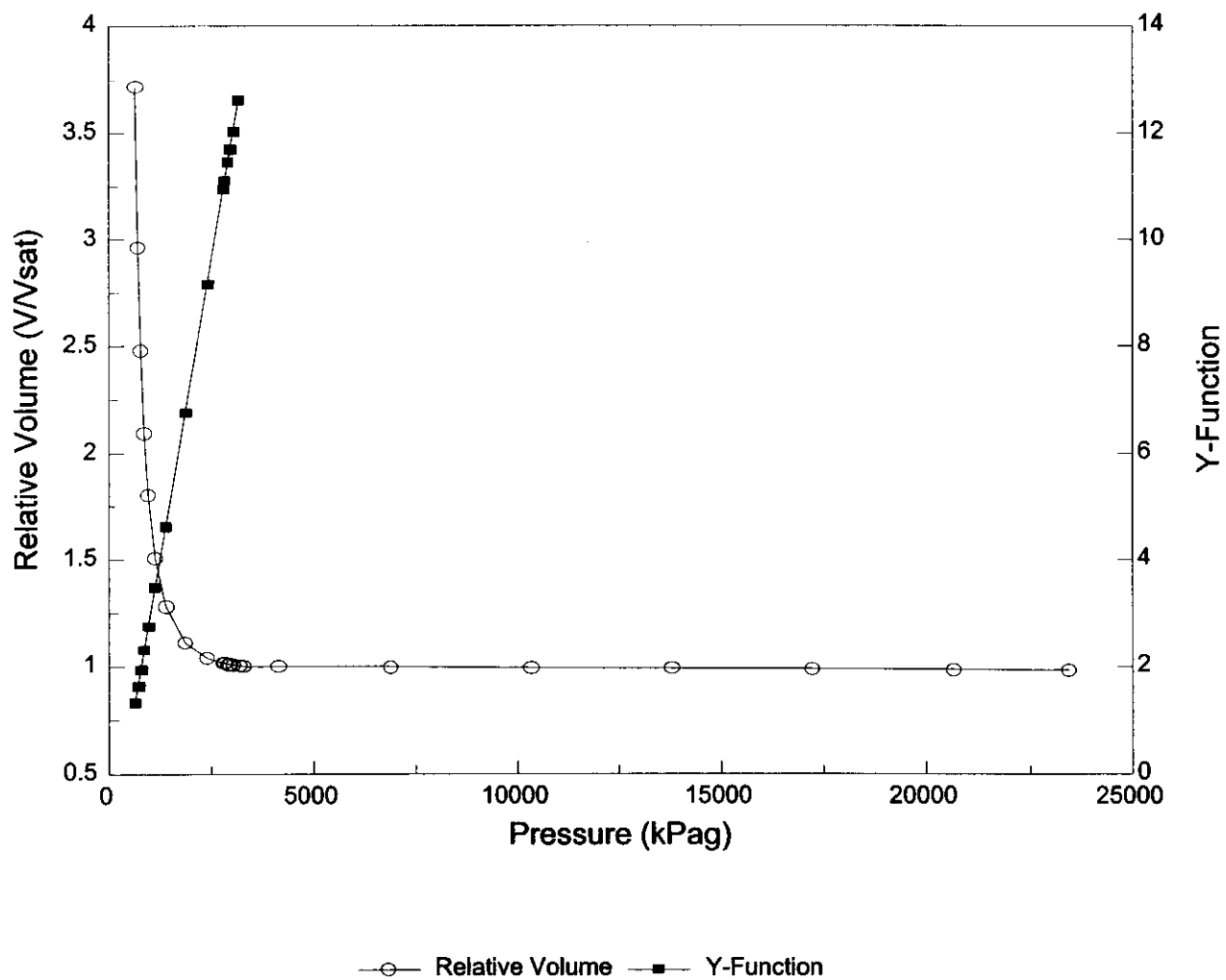
Boiling Point (°C)	Component		Mole Fraction	Mass Fraction	
-195.8	Nitrogen	N ₂	0.0000	0.0000	Calculated Properties of Total Sample
-78.51	Carbon Dioxide	CO ₂	0.0000	0.0000	
-60.31	Hydrogen Sulphide	H ₂ S	0.0000	0.0000	
-161.7	Methane	C ₁	0.0000	0.0000	
-88.9	Ethane	C ₂	0.0000	0.0000	Molecular Weight 237.45
-42.2	Propane	C ₃	0.0042	0.0008	Calculated Properties of C ₄₊ Fraction
-11.7	i-Butane	i-C ₄	0.0027	0.0007	
-0.6	n-Butane	n-C ₄	0.0324	0.0079	
27.8	i-Pentane	i-C ₅	0.0254	0.0077	
36.1	n-Pentane	n-C ₅	0.0333	0.0101	C ₆₊ Molecular Weight 256.10
36.1 - 68.9	Hexanes	C ₆	0.0618	0.0224	C ₆₊ Mole Fraction 0.9020
68.9 - 98.3	Heptanes	C ₇	0.1096	0.0463	C ₆₊ Density (g/cc) 0.8937
98.3 - 125.6	Octanes	C ₈	0.0799	0.0384	Calculated Properties of C ₇₊ Fraction
125.6 - 150.6	Nonanes	C ₉	0.0598	0.0323	
150.6 - 173.9	Decanes	C ₁₀	0.0615	0.0368	
173.9 - 196.1	Undecanes	C ₁₁	0.0577	0.0357	
196.1 - 215.0	Dodecanes	C ₁₂	0.0474	0.0321	C ₇₊ Molecular Weight 268.60
215.0 - 235.0	Tridecanes	C ₁₃	0.0442	0.0326	C ₇₊ Mole Fraction 0.8402
235.0 - 252.2	Tetradecanes	C ₁₄	0.0357	0.0285	C ₇₊ Density (g/cc) 0.9002
252.2 - 270.6	Pentadecanes	C ₁₅	0.0303	0.0263	
270.6 - 287.8	Hexadecanes	C ₁₆	0.0261	0.0244	
287.8 - 302.8	Heptadecanes	C ₁₇	0.0254	0.0253	
302.8 - 317.2	Octadecanes	C ₁₈	0.0212	0.0224	
317.2 - 330.0	Nonadecanes	C ₁₉	0.0186	0.0206	
330.0 - 344.4	Eicosanes	C ₂₀	0.0164	0.0190	
344.4 - 357.2	Heneicosanes	C ₂₁	0.0147	0.0181	
357.2 - 369.4	Docosanes	C ₂₂	0.0136	0.0174	
369.4 - 380.0	Tricosanes	C ₂₃	0.0120	0.0160	
380.4 - 391.1	Tetracosanes	C ₂₄	0.0106	0.0148	
391.1 - 401.7	Pentacosanes	C ₂₅	0.0094	0.0137	
401.7 - 412.2	Hexacosanes	C ₂₆	0.0089	0.0134	
412.2 - 422.2	Heptacosanes	C ₂₇	0.0076	0.0119	
422.2 - 431.7	Octacosanes	C ₂₈	0.0071	0.0116	
431.7 - 441.1	Nonacosanes	C ₂₉	0.0065	0.0110	
Above 441.1	Tricontanes Plus	C ₃₀₊	0.0515	0.3742	
Naphthenes					
48.9	Cyclopentane	C ₅ H ₁₀	0.0000	0.0000	
72.2	Methylcyclopentane	C ₆ H ₁₂	0.0172	0.0061	
81.1	Cyclohexane	C ₆ H ₁₂	0.0000	0.0000	
101.1	Methylcyclohexane	C ₇ H ₁₄	0.0079	0.0033	
Aromatics					
80	Benzene	C ₆ H ₆	0.0009	0.0003	
110.6	Toluene	C ₇ H ₈	0.0037	0.0015	
136.1 - 138.9	Ethylbenzene, p&m-Xylene	C ₈ H ₁₀	0.0174	0.0078	
144.4	o-Xylene	C ₈ H ₁₀	0.0066	0.0029	
168.9	1,2,4-Trimethylbenzene	C ₉ H ₁₂	0.0108	0.0055	
Total			1.0000	1.0000	

TABLE 12
ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
PVT DATA ADJUSTMENT

Pressure (kPag)	PVT Data		Adjusted Data	
	B _o	GOR (m ³ /m ³)	B _o	GOR (m ³ /m ³)
10342	1.1062	27.75	1.0889	25.50
3300	1.1135	27.75	1.0960	25.50
2758	1.1077	25.16	1.0903	22.96
2068	1.1001	21.49	1.0828	19.34
1379	1.0929	18.98	1.0758	16.87
689	1.0815	13.56	1.0646	11.53
345	1.0720	10.18	1.0552	8.21
0	1.0231	0.00	1.0070	0.00

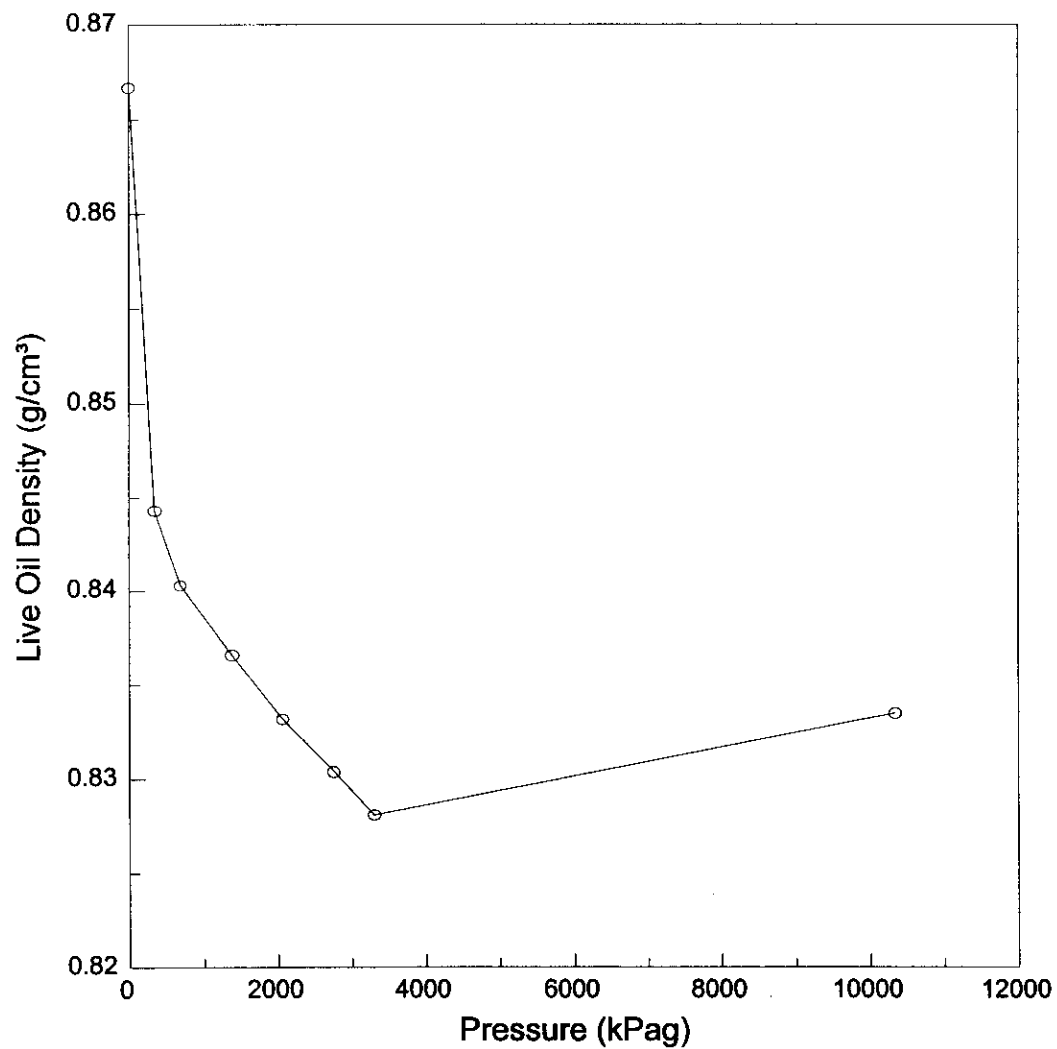
FIGURES

FIGURE 1
ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
RELATIVE VOLUME VS PRESSURE



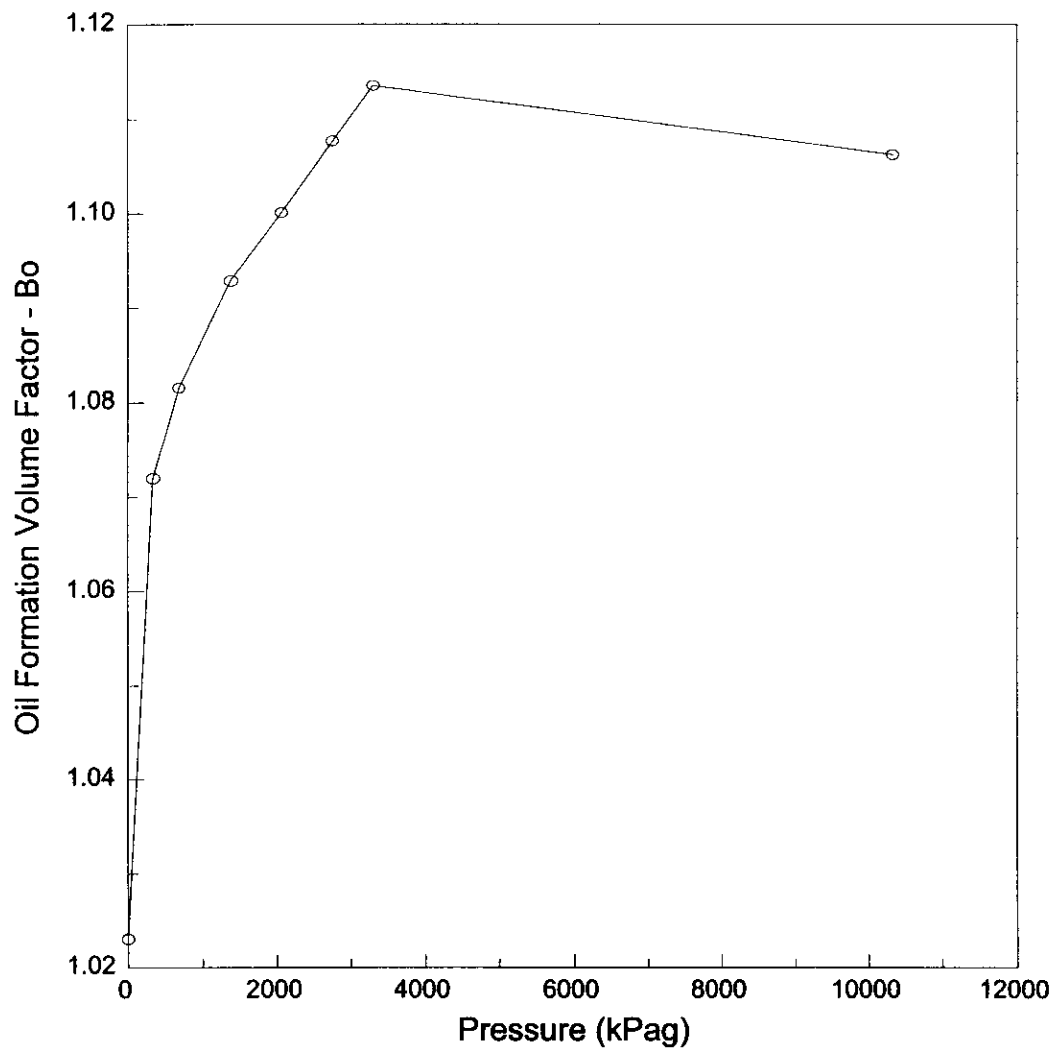
99-143B

FIGURE 2
ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
LIVE OIL DENSITY VS PRESSURE



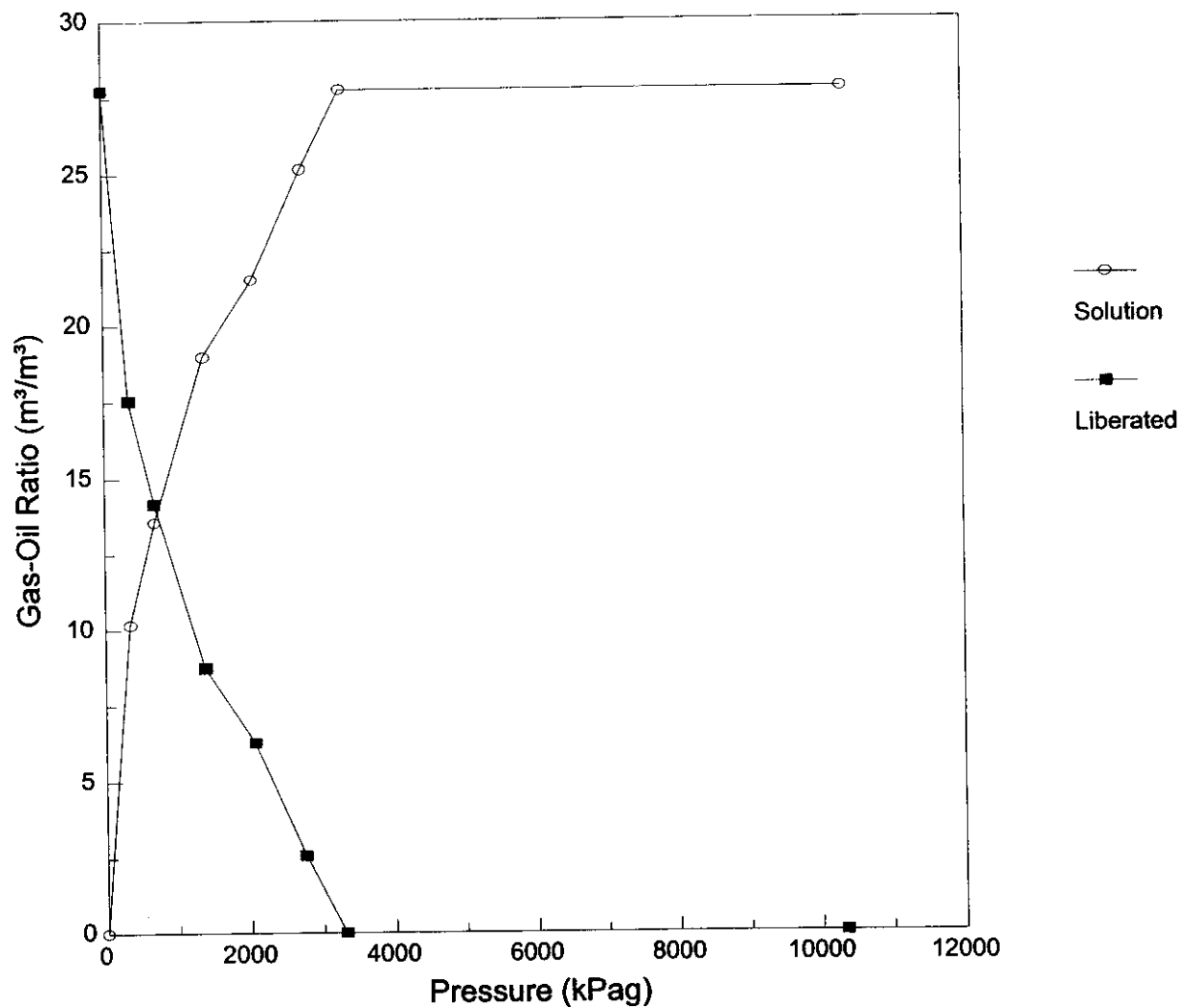
99-143B

FIGURE 3
ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
OIL FORMATION VOLUME FACTOR VS PRESSURE



99-143B

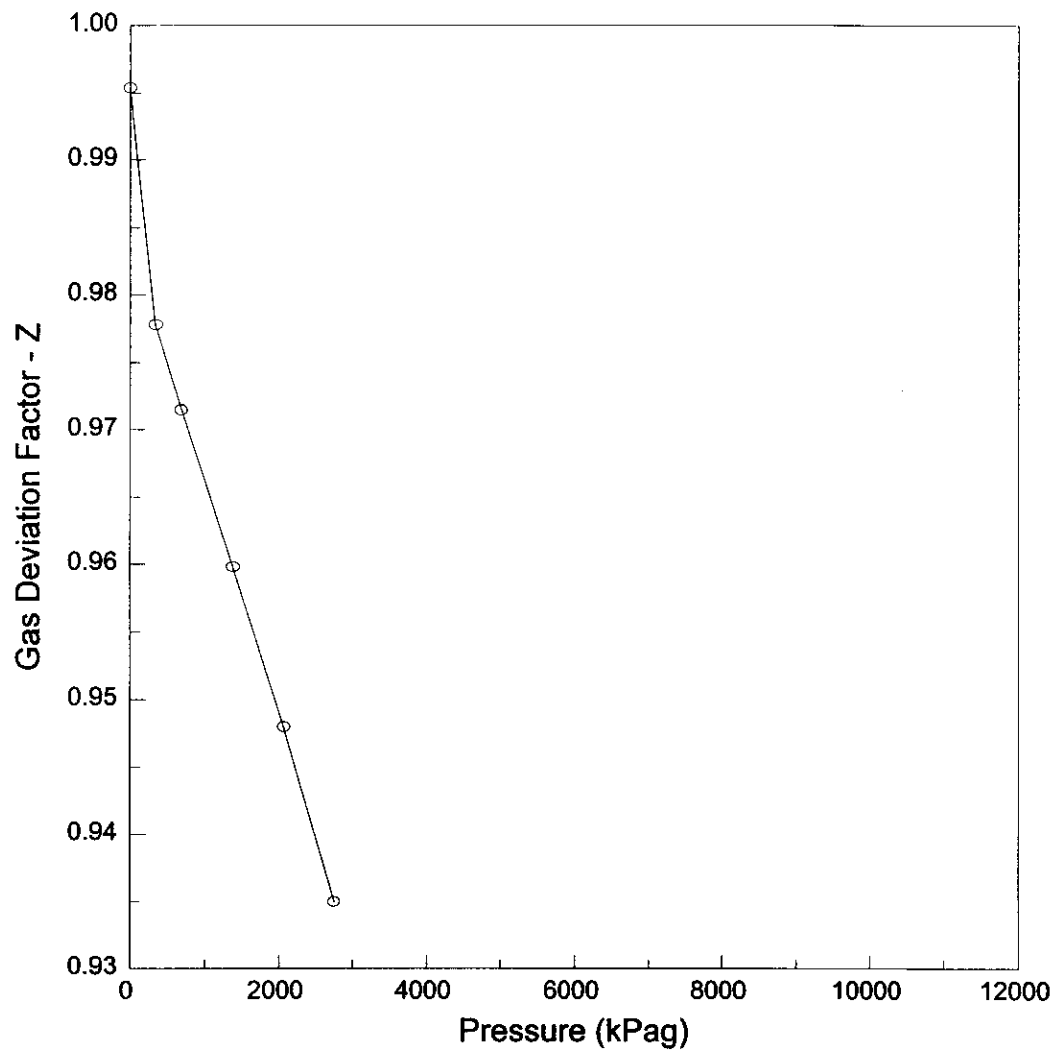
FIGURE 4
ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
LIBERATED & SOLUTION GAS-OIL RATIO VS PRESSURE



99-143B

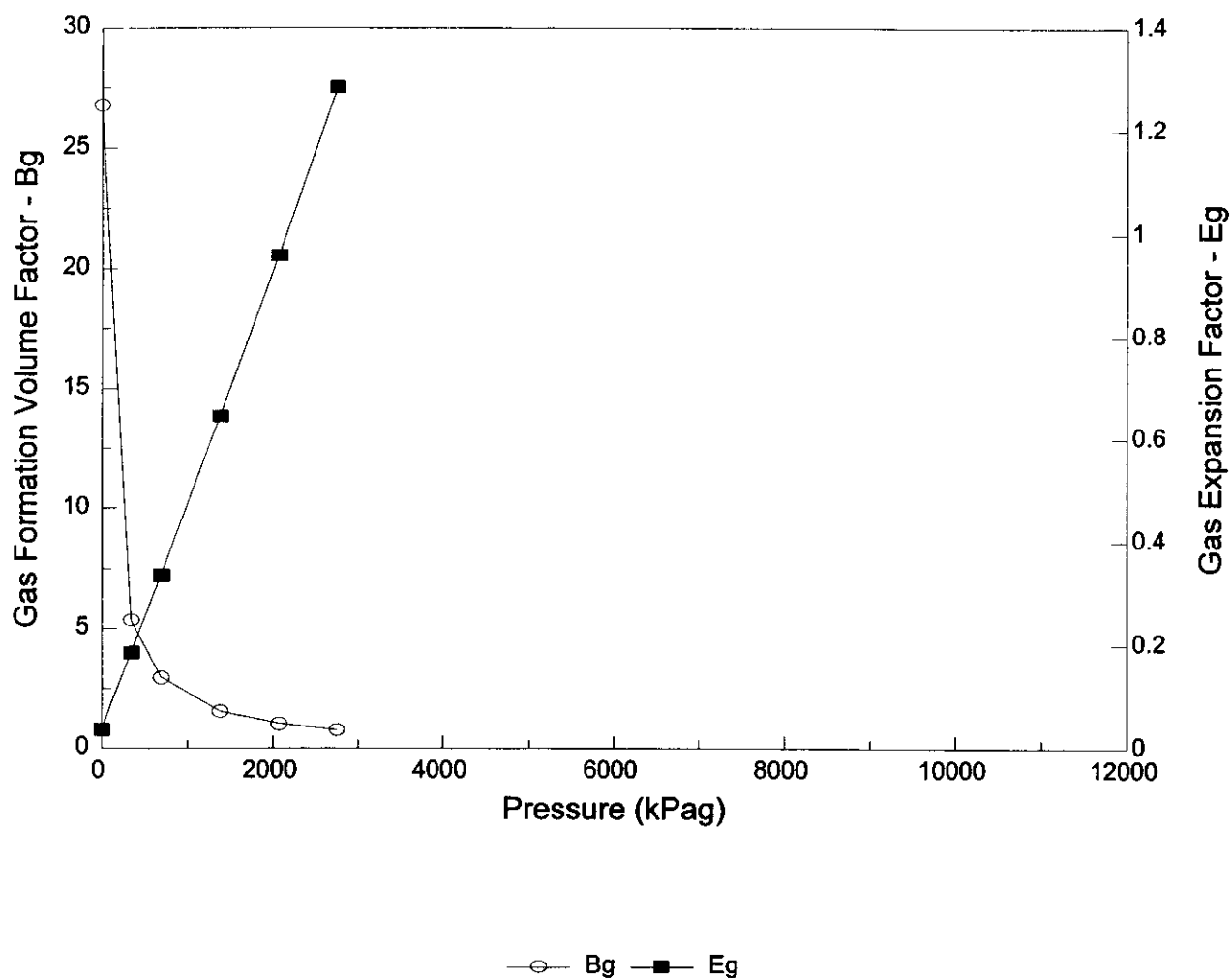
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FIGURE 5
ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
GAS DEVIATION FACTOR VS PRESSURE



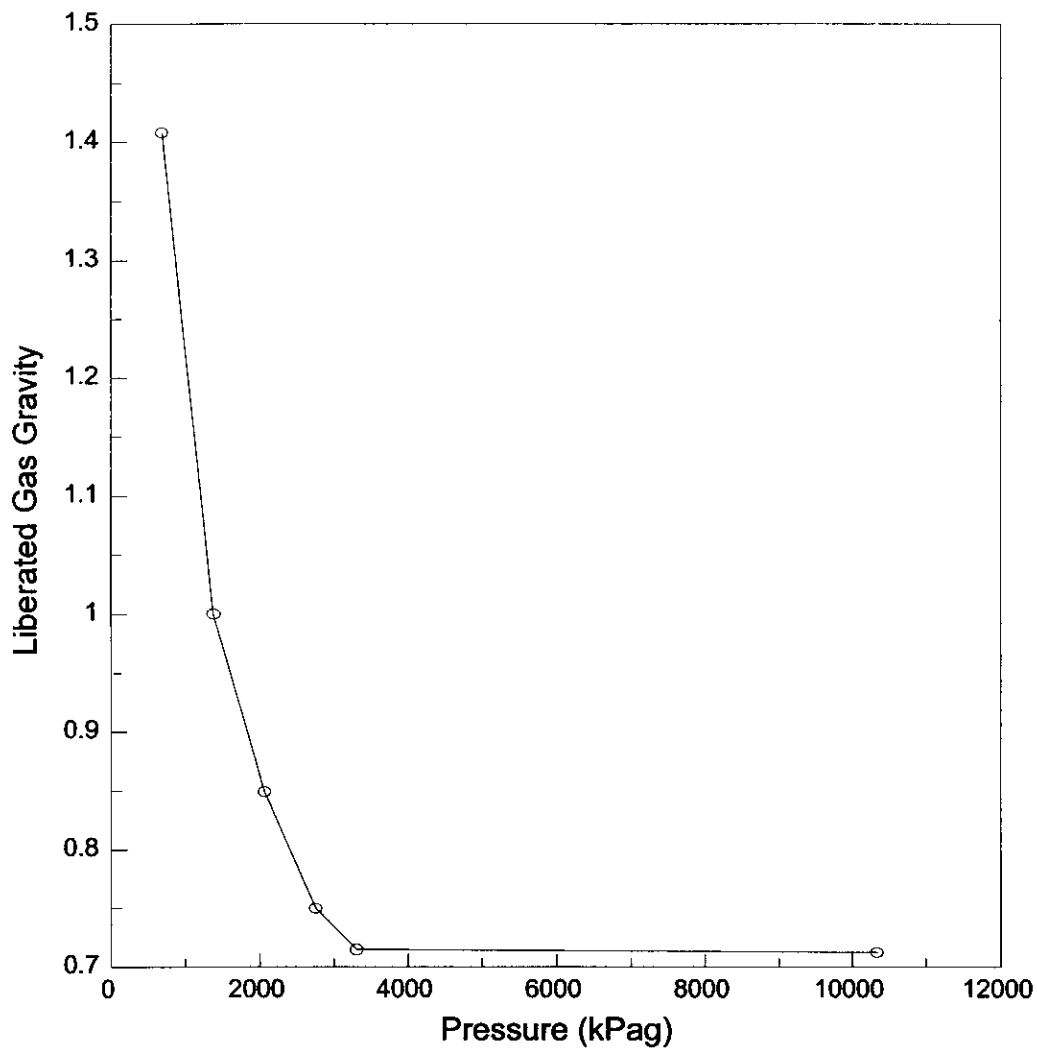
99-143B

FIGURE 6
ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
GAS FORMATION VOLUME & EXPANSION FACTOR VS PRESSURE



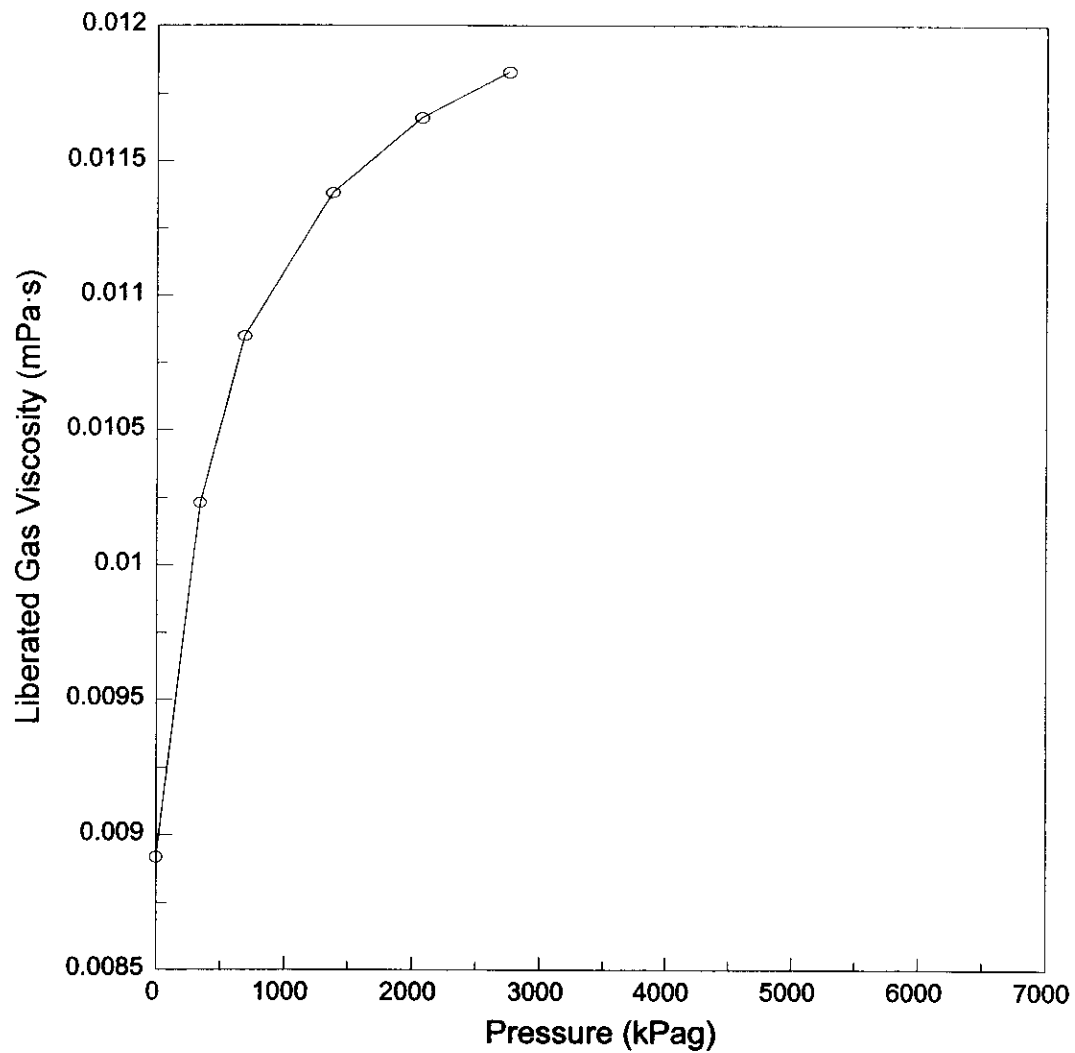
99-143B

FIGURE 7
ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
LIBERATED GAS GRAVITY VS PRESSURE



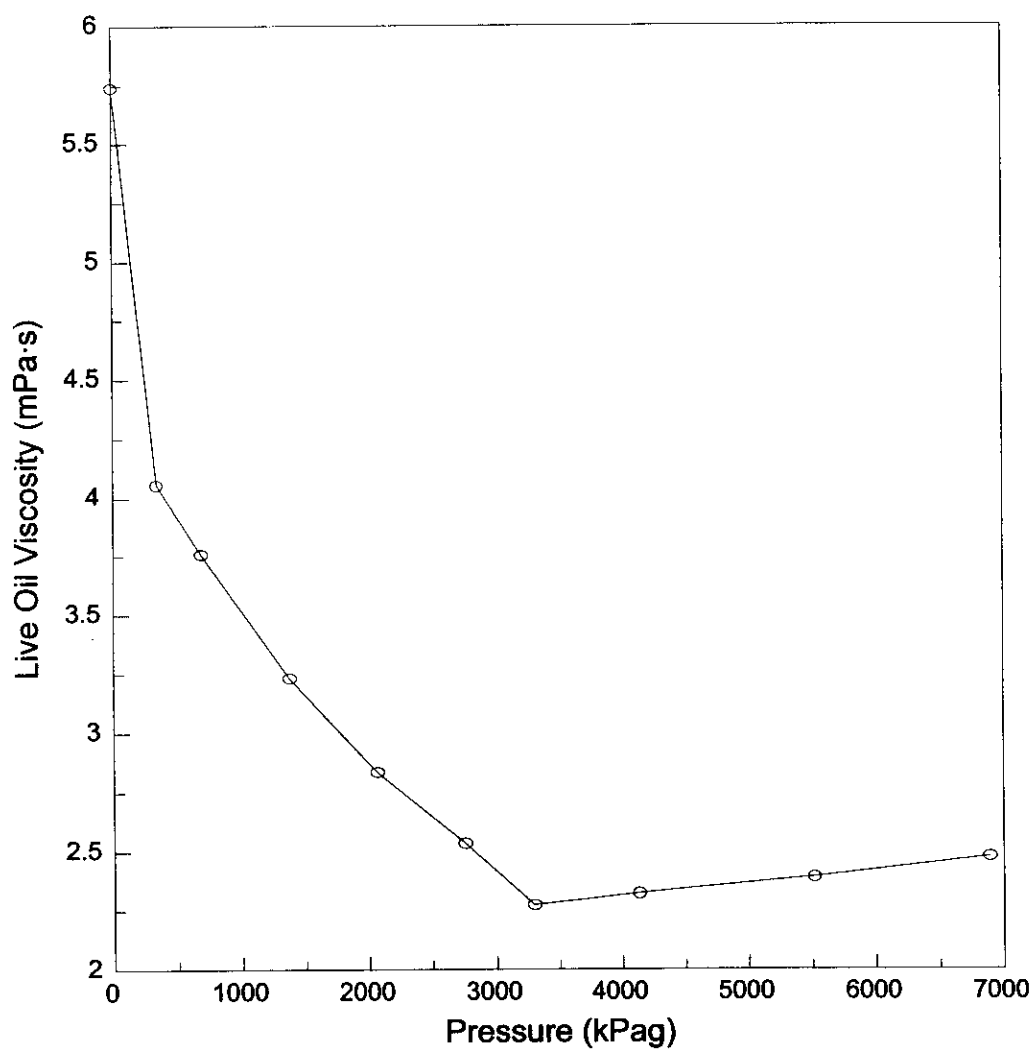
99-143B

FIGURE 8
ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
LIBERATED GAS VISCOSITY VS PRESSURE



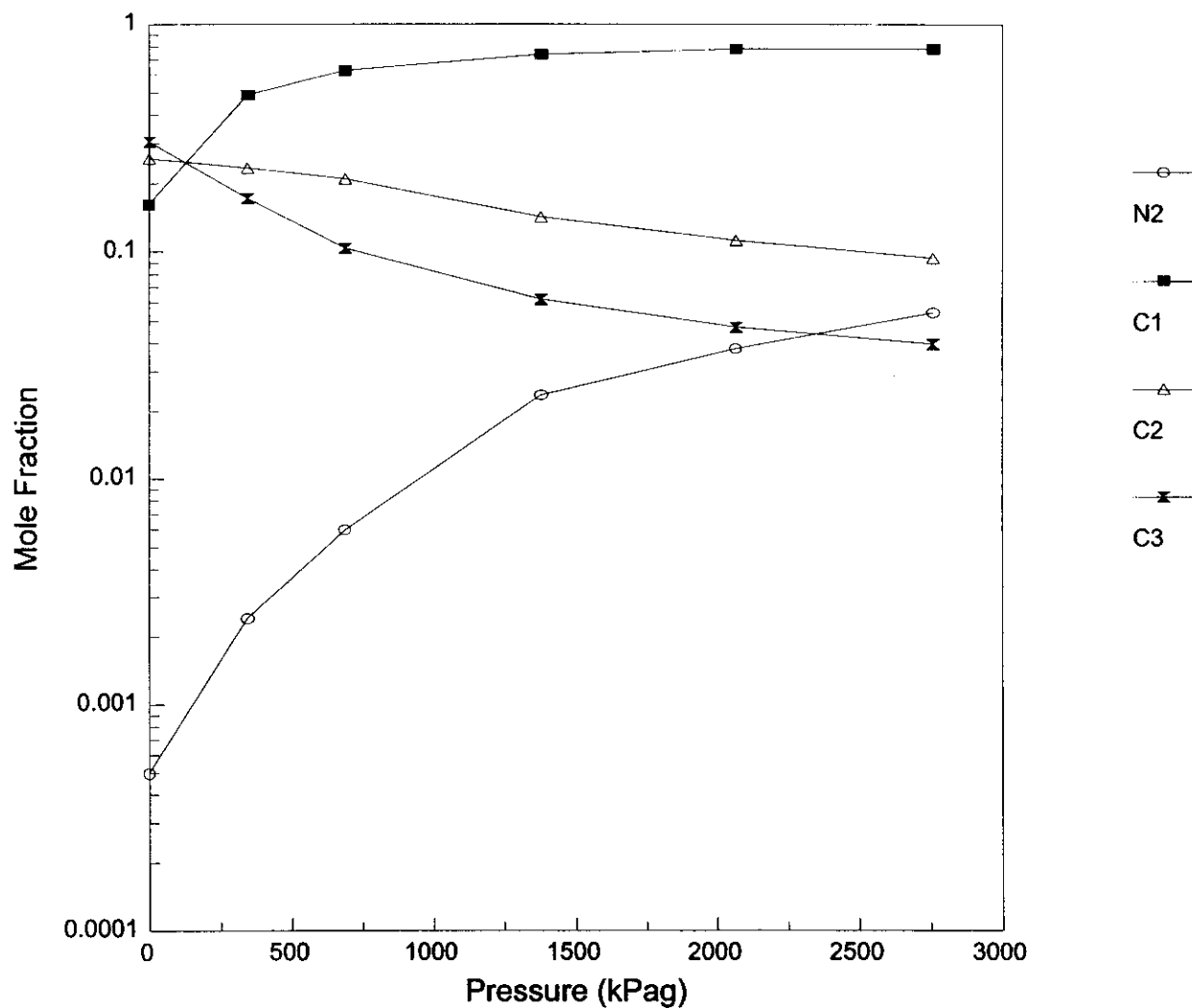
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FIGURE 9
ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
LIVE OIL VISCOSITY VS PRESSURE



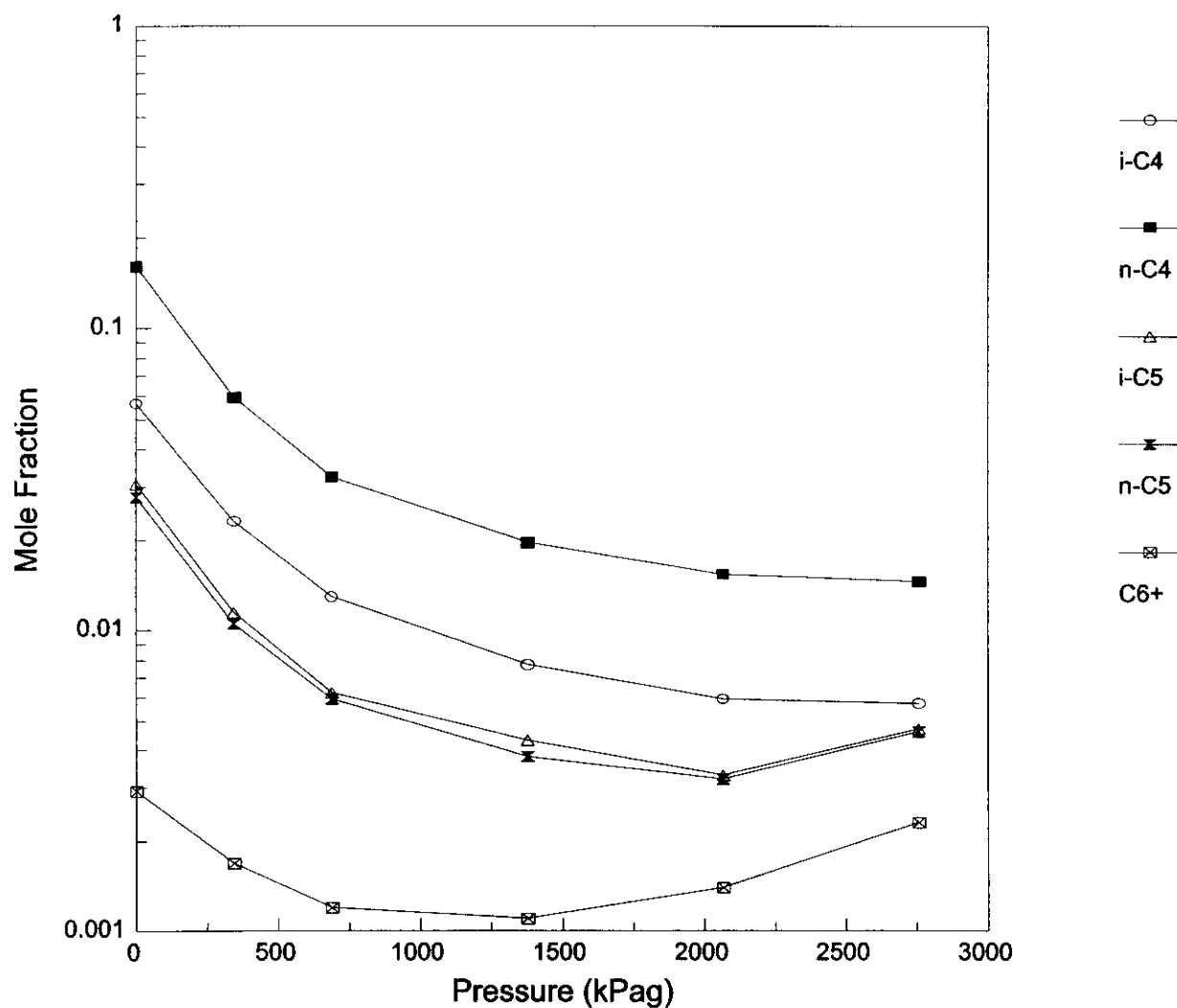
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FIGURE 10
ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
LIBERATED GAS COMPOSITION PROFILE (1 OF 2)



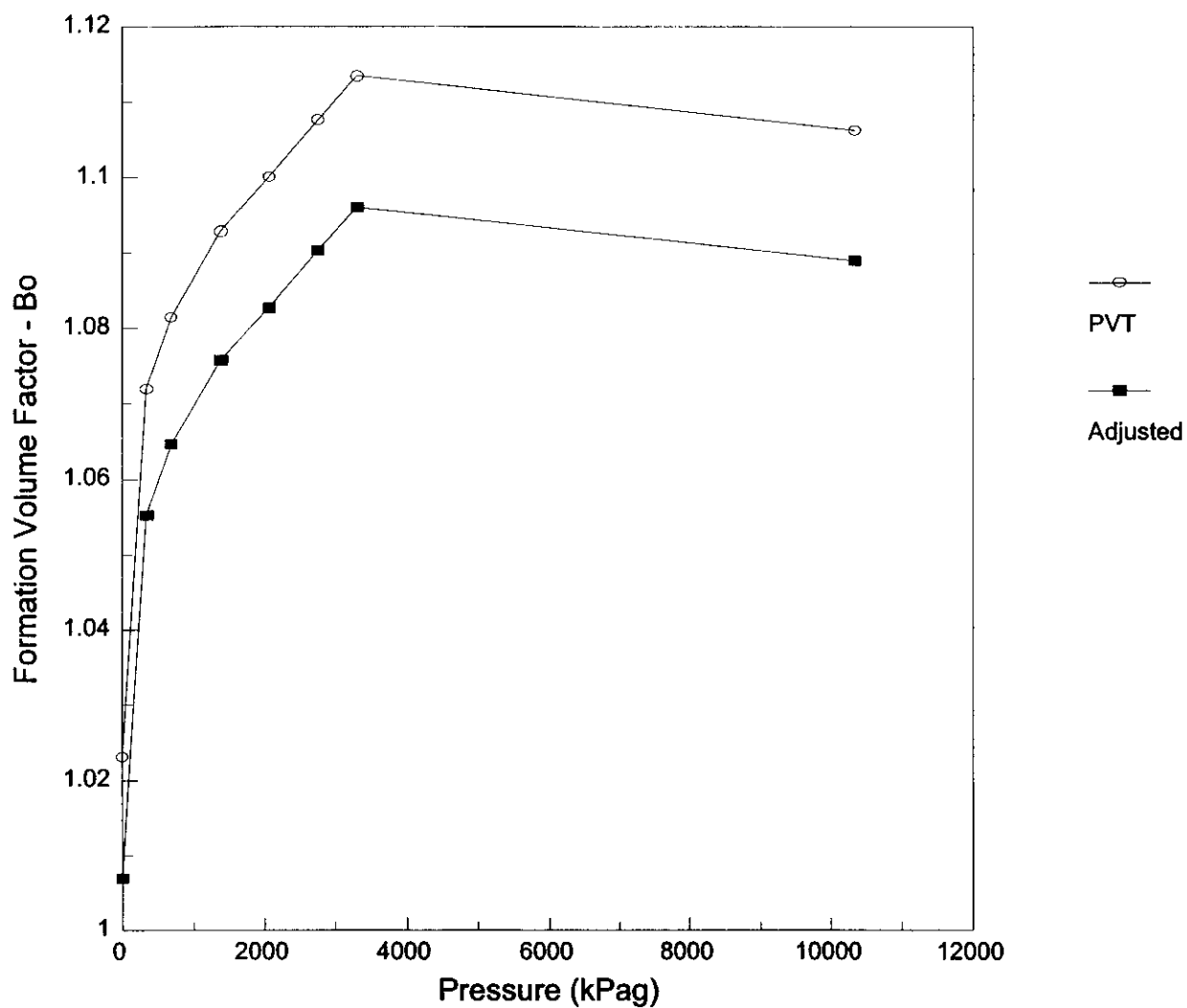
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FIGURE 11
ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
LIBERATED GAS COMPOSITION PROFILE (2 OF 2)



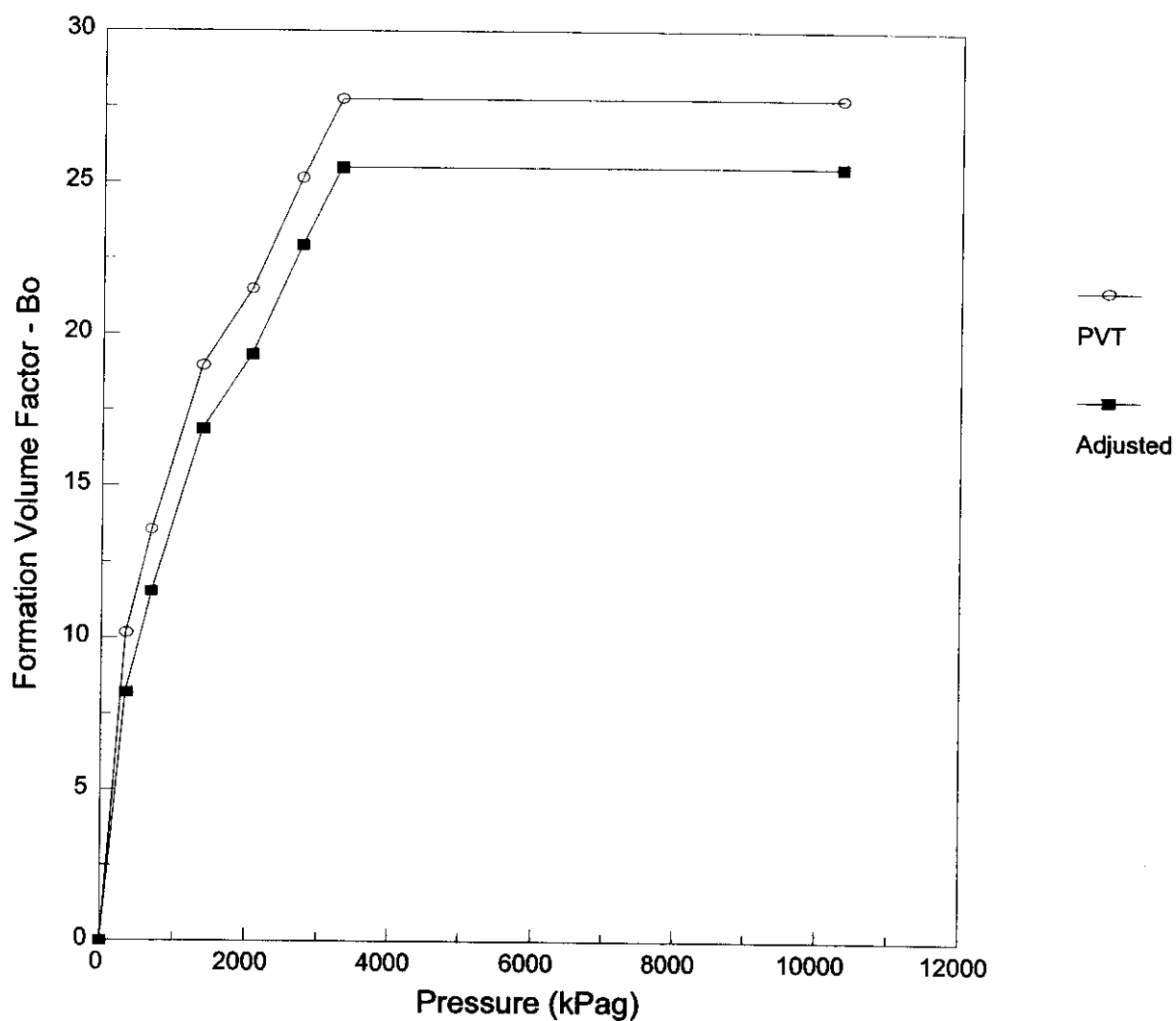
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FIGURE 12
ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
PVT AND FLASH ADJUSTED FORMATION VOLUME FACTOR



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FIGURE 13
ANDERSON - PIERSON
WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
PVT AND FLASH ADJUSTED GAS-OIL RATIO



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FIGURE 14
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RESERVOIR FLUID STUDY
CONDENSATION STATION

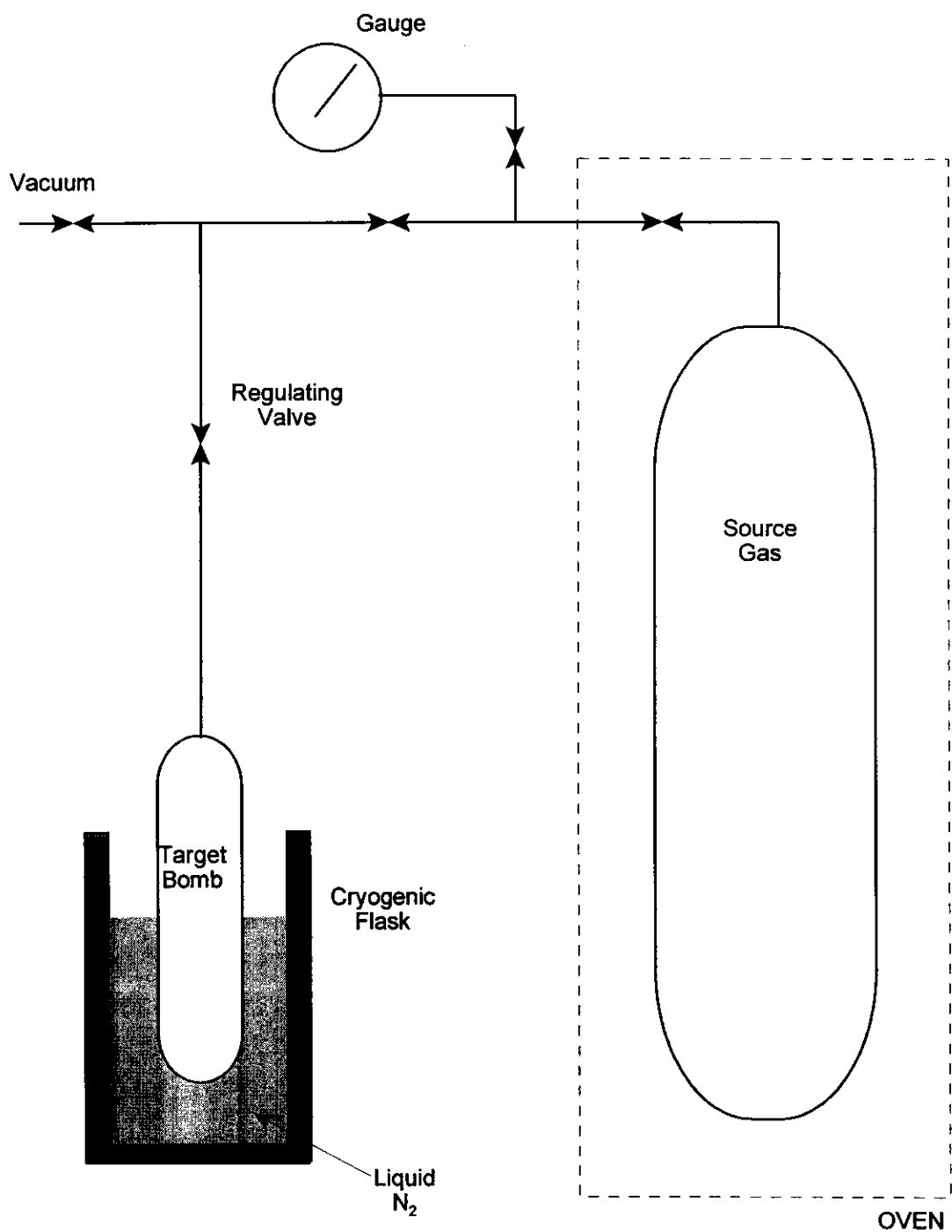


FIGURE 15
ANDERSON - PIERSON
RESERVOIR FLUID STUDY
DIFFERENTIAL LIBERATION PROCEDURE SCHEMATIC

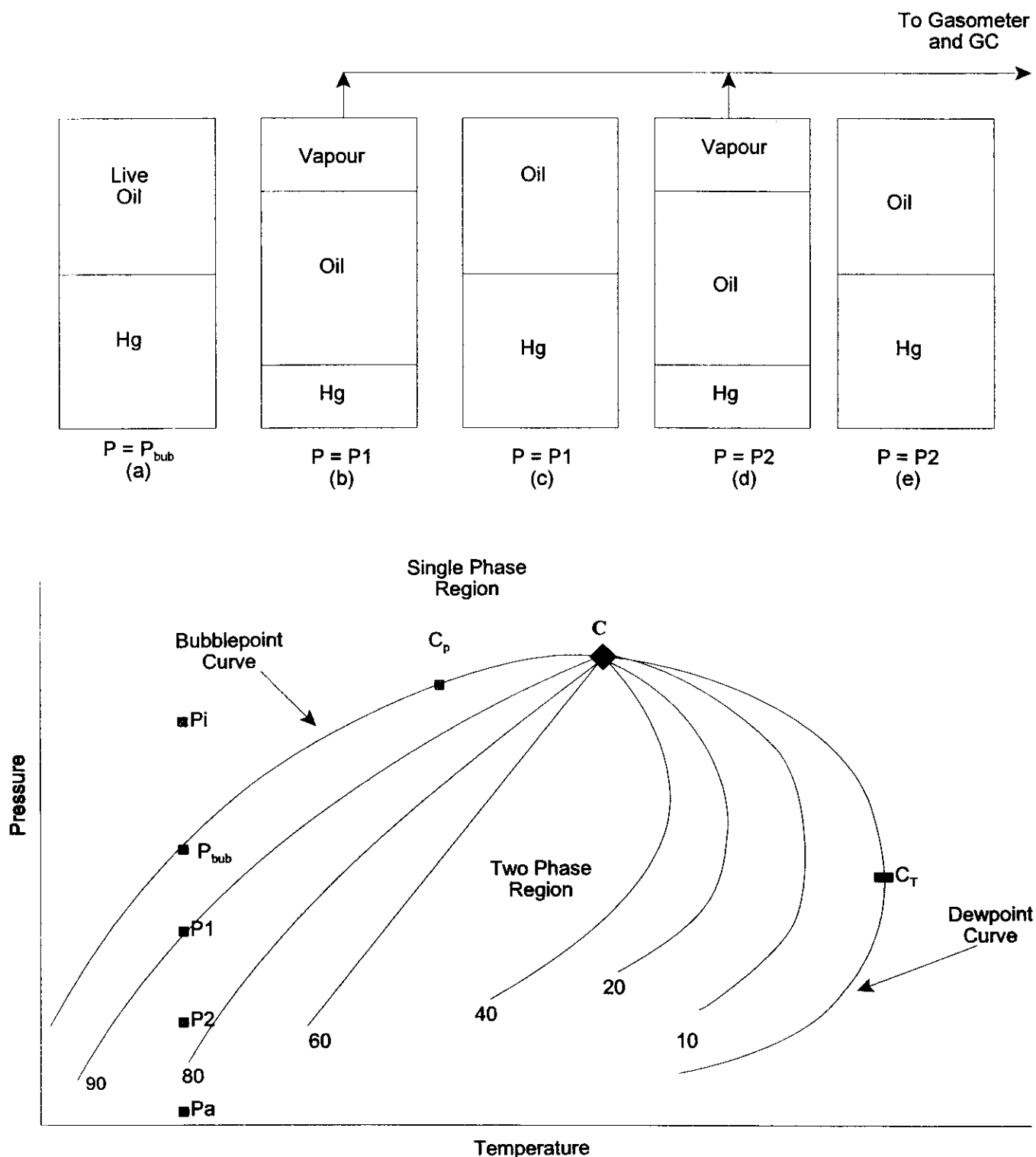
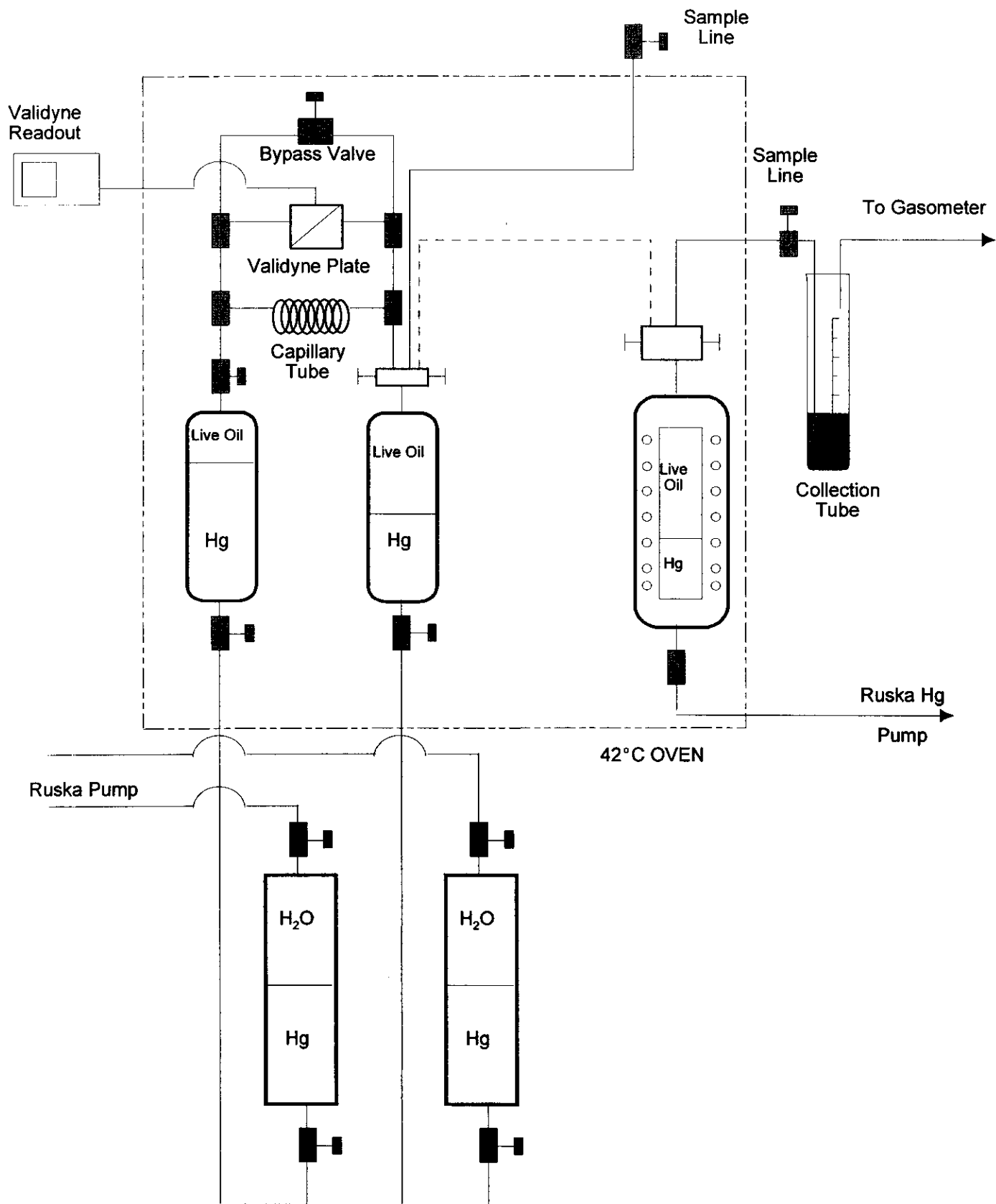


FIGURE 16
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DIFFERENTIAL LIBERATION EQUIPMENT SCHEMATIC



APPENDICES

APPENDIX A
Formation Volume Factors

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APPENDIX A

Formation Volume Factors

To test for the intrinsic consistency of a differential liberation experiment, or for that matter any process involving a so-called flash, one can calculate theoretically the mass balance. To have as close to zero experimental error as possible one must be able to close this mass balance to within a desired tolerance. One of the standard checks applied to such processes is the calculation of a theoretical formation volume factor from theoretical constructs. That is:

1. We take as our basis 1 m^3 of residual stock tank oil from a differential liberation process. By definition that 1 m^3 of residual stock tank oil has an associated mass equal to the density of that stock tank oil. For example, for a 40° API oil after differential liberation process at stock tank oil conditions, the mass associated with 1 m^3 of that oil would be 825 kg.
2. During the process of vaporization in a differential manner a cumulative volume of gas has been evolved. At each step gas of changing composition has been evolved and therefore associated with the volume of gas is a mass of gas which will change in density as a function of pressure level. Therefore, in order to associate all of the gas which has been evolved from initial reservoir fluid composition down to residual dead oil, we must calculate the gas evolved at each step and include the molecular weight of that gas in order to correctly account for the mass at each stage. Since the basis is 1 m^3 of residual oil, these gas volumes are simply related to the GOR changes from step to step.
3. Having said that, one can see that we have associated a residual dead oil mass plus the total mass of gas evolved during differential vaporization from the original reservoir fluid composition. We know that the gas and the oil mixed in a very non-ideal manner and therefore it is difficult to associate an accurate volume that the gas and oil would occupy when in equilibrium at the bubblepoint pressure unless we have measured experimentally a separate value. That separate value is the density of the reservoir fluid at bubblepoint pressure. Thus the density measured of the reservoir fluid at its bubblepoint represents the total volume associated with the mass of that oil plus gas. Thus the sum of the mass associated with the dead oil plus the total flash gas divided by the density of the reservoir fluid at its bubblepoint will equal the volume of that oil plus the gas at saturation pressure.
4. Because the volume of that oil plus gas had as its basis 1 m^3 of residual oil at stock tank conditions having been derived from the differential vaporization process, that volume divided by 1 m^3 of the dead oil represents the formation volume factor by definition. Therefore, this material balance check is what has been applied throughout this report and has been used to establish and confirm the inherent consistency of this data set.

Mathematically, the material balance in terms of B_o , in its fully expanded form, appears as:

$$B_{o,i} = \frac{DOD + 1.228 [R_{s,o} G_o - (R_{s,o} - R_{s,i}) G_i]}{LOD_i}$$

where:

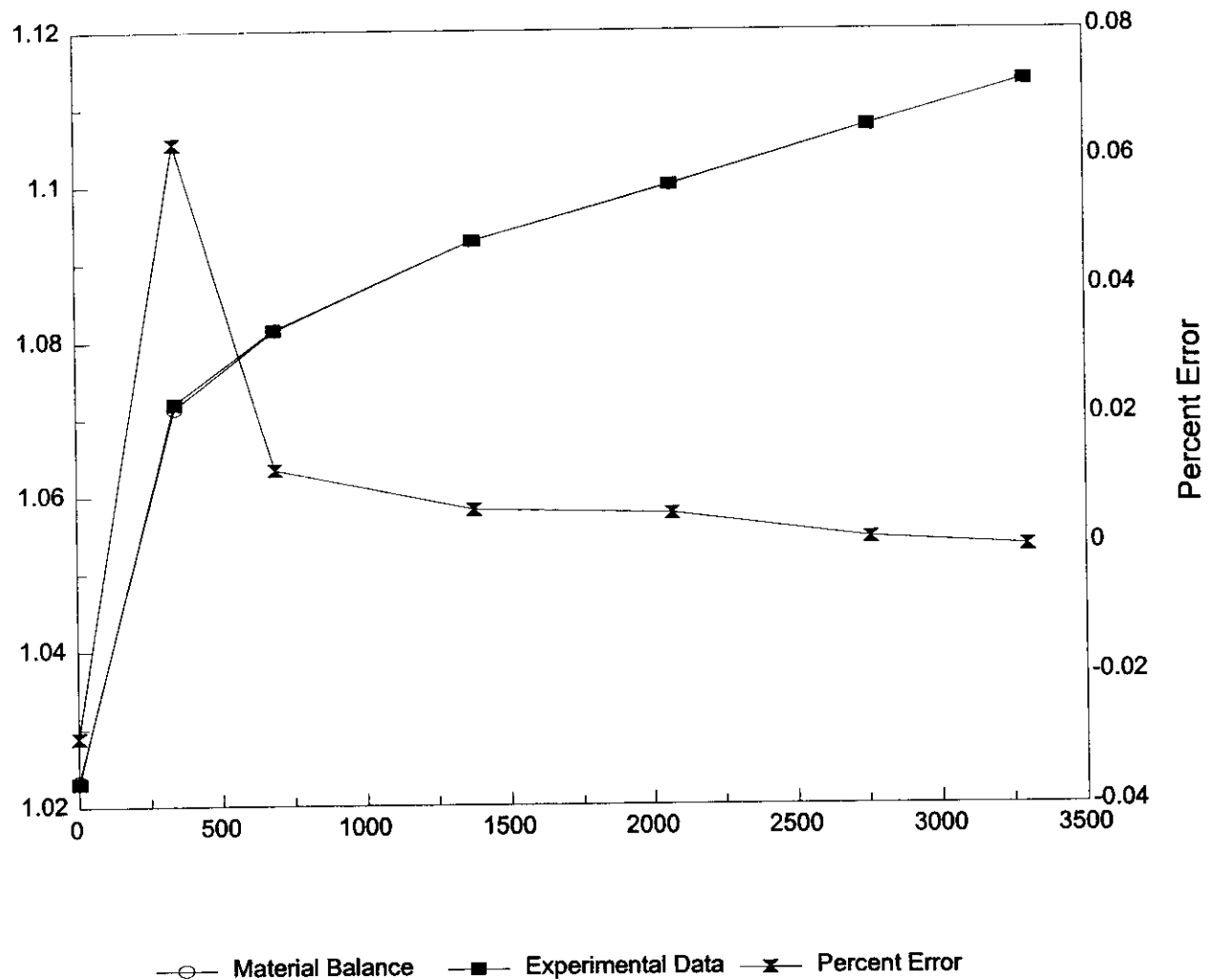
- $B_{o,i}$ = formation volume factor at pressure stage i
- DOD = residual dead oil density (kg/m^3)
- $R_{s,o}$ = solution gas-oil ratio at the bubblepoint (m^3/m^3)
- $R_{s,i}$ = solution gas-oil ratio at pressure stage i below the bubblepoint (m^3/m^3)
- G_o = total cumulative liberated gas gravity
- G_i = cumulative liberated gas gravity to pressure stage i
- LOD_i = live oil density at pressure stage i (kg/m^3)

At the bubblepoint (stage 0), this equation reduces to:

$$B_o = \frac{DOD + 1.228 R_{s,o} G_o}{LOD_o}$$

The following figure displays the material balance closure on a point by point basis as calculated from the above equations.

FIGURE A1
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WELL 7-17-2-29 W1M
RESERVOIR FLUID STUDY
B_o - MATERIAL BALANCE CHECK



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