0338

Litton
Core Lab

Reservoir Fluid Study
for
Tenneco Oil Exploration & Production
Phoenix No. 1

RFL 1016

Litton
Core Lab

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Houston, Texas
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February 4, 1987

Tenneco Oil Exploration & Production
Frontier Division
P. O. Box 2511
1100 Milam
Houston, Texas 77001

ATTN: Brady McConaty

Subject: Reservoir Fluid Study
Crude Oil & Water Analyses
Well: Phoenix No.1
State: Alaska
File No: RFL 1016

Gentlemen:

Presented in this report are the results of a partial reservoir fluid study in addition to crude oil and water analyses performed on samples collected from the subject well in December, 1986.

Thank you for the opportunity to be of service to Tenneco Oil Exploration & Production Co. If you have any questions or if we may be of further assistance to you in any way, please do not hesitate to call at your convenience.

Sincerely,

Larry W. Scott
Supervisor
Reservoir Fluid Laboratory

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Laboratory Procedures

Tenneco Oil Exploration & Production
Reservoir Fluid Study
Phoenix No. 1
RFL 1016

Crude Oil Samples

Several samples of stock tank oil were selected for routine crude oil characterization and analyzed for paraffin content and asphaltenes.

Water Samples

Mineral patterns and associated water properties were measured on selected samples of water produced during the testing. The results of these analyses are appended to this report.

Separator Samples

Separator gases were collected at the well for possible use in laboratory tests. A compositional analysis of the field gas is provided on page four of the report.

Reservoir Fluid Sample

A DST sample of reservoir fluid was shipped to our Anchorage facility for transfer to laboratory cylinders. Opening pressure on the tool was found to be approximately 500 psig at 70°F after expansion of the sample into the guage manifold and a small amount of sample loss. The pressure on the tool was increased to 2000 psi by injecting approximately 130 cc's of water into the 2500 cc chamber and agitated before transfering to two storage cylinders. The volume of water necessary to repressure the tool indicated that it initially contained oil and a small amount of gas at 500 psig. Evaluation of the tool's pressure and contents indicated that the sample could be considered a reasonably valid representation of the reservoir fluid.

Upon arrival of the two reservoir fluid samples in our Houston laboratory, the room temperature bubble points were found to be 511 and 512 psig at 70°F. These values were considered to be in good agreement with each other and indicated that any free gas present in the DST had been redissolved in the oil phase prior to the sample transfer.

The hydrocarbon composition of the subsurface fluid sample was determined and is reported on page three. It should be noted that the sample contained small amounts of hydrogen and carbon monoxide which are not normally present in reservoir fluid samples. These contaminents would be expected to have a small effect on the physical properties measured for the sample.

A portion of the reservoir fluid was examined in a visual cell at the reservoir temperature of 110° F. and found to exhibit a bubble point at 584 psig. The volumetric data and pressure volume relations of the reservoir fluid are summarized on pages five and six.

The viscosity of the reservoir fluid was measured over a wide range of pressures at 110° F. in a rolling ball viscosimeter. The viscosity of the fluid was found to vary from a minimum of 26.34 centipoises at the saturation pressure to a maximum of 43.21 centipoises at atmospheric pressure. The results of the viscosity measurements are tabulated on page seven.

A single-stage separator test was performed in order to determine gas-oil ratios and the oil formation volume factor. The separator gas from this test was collected and analysed and is presented on page nine of the report.

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Company Tenneco File Number RFL 1016

Well Phoenix No.1 County

Field State Alaska

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Well Phoenix No.1

WELL INFORMATION

Formation Characteristics

Formation Name	
Date First Well Completed	,19
Original Reservoir Pressure	PSIG at Ft.
Original Produced Gas-Oil Ratio	SCF/Bbl
Production Rate	Bbl/Day
Separator Pressure & Temperature	PSIG °F.
Oil Gravity at 60°F.	°API
Datum	Ft.Subsea
Original Gas Cap	

Well Characteristics

Elevation	Ft.
Total Depth	Ft.
Producing Interval	Ft.
Tubing Size and Depth	In. to Ft.
Productivity Index	Bbl/D/PSI at Bbl/Day
Last Reservoir Pressure	Approx. 1800 PSIG at Ft.
Date	,19
Reservoir Temperature	110 °F. at Ft.
Status of Well	
Pressure Gauge	
Normal Production Rate	Bbl/Day
Gas-Oil Ratio	SCF/Bbl
Separator Pressure & Temperature	PSIG, °F.
Base Pressure	15.025 PSIA
Well Making Water	% Cut

Sampling Conditions

Sampled at	Ft.
Date Sampled	
Status of Well	
Gas-Oil Ratio	SCF/Bbl
Separator Pressure & Temperature	PSIG, °F.
Tubing Pressure	PSIG
Casing Pressure	PSIG
Sampled by	Floepetrol
Type Sampler	DST

File RFL 1016

Well Phoenix No.1

SUMMARY OF PVT SAMPLES RECEIVED IN LABORATORY

Separator Gas

	Separator Conditions		Laboratory Opening Conditions	
Cylinder Number	Pressure, Psig	Temperature, °F.	Pressure, Psig	Temperature, °F.
CLH 439*	18	70	18	70
CLH 443	12	70	12	70

Drill Stem Test Reservoir Fluid

	Laboratory Bubble Point Pressure	
Cylinder Number	Pressure, Psig	Temperature, °F.
289446D*	511	70
188479D	512	70

* Used in this study

File RFL 1016

Well Phoenix No.1

COMPOSITION OF RESERVOIR FLUID SAMPLE

Component	Mol Percent	Weight Percent	Density, Gm/Cc at 60°F.	°API at 60°F.	Molecular Weight
Hydrogen *	0.09	0.02			
Carbon Monoxide *	0.53	0.06			
Carbon Dioxide	0.01	Trace			
Nitrogen	0.81	0.09			
Methane	11.25	0.68			
Ethane	0.92	0.11			
Propane	1.28	0.22			
iso-Butane	0.54	0.12			
n-Butane	0.84	0.19			
iso-Pentane	0.80	0.22			
n-Pentane	0.70	0.19			
Hexanes	1.60	0.51			
Heptanes Plus	80.63	97.59	0.9310	20.3	317
	100.00	100.00			

Average Molecular Weight = 263.36

* Components not normally found in reservoir fluids

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Well Phoenix No.1

HYDROCARBON ANALYSIS OF FIELD SEPARATOR GAS SAMPLE

COMPONENT	MOL PERCENT	GPM
Hydrogen Sulfide	Nil	
Carbon Dioxide	0.19	
Nitrogen	1.11	
Methane	85.04	
Ethane	4.49	1.225
Propane	4.67	1.313
iso-Butane	1.27	0.424
n-Butane	1.54	0.495
iso-Pentane	0.71	0.265
n-Pentane	0.46	0.170
Hexanes	0.30	0.119
Heptanes plus	0.22	0.099
	100.00	4.110

Calculated gas gravity= 0.704

Calculated Gross Heating Value= 1248 BTU per cubic foot of dry gas
@ 15.025 psia and 60 °F.

Collected at 18 psig and 50°F.

PRESSURE-VOLUME RELATIONS AT 110°F.

Pressure Psig	Relative Volume (1)	Y Function (2)	Density, Gm/Cc
5000	0.9816		0.9199
4000	0.9850		0.9168
3000	0.9887		0.9133
2000	0.9929		0.9095
1800 Pr	0.9938		0.9086
1500	0.9952		0.9074
1000	0.9977		0.9051
900	0.9982		0.9046
800	0.9988		0.9041
700	0.9993		0.9036
600	0.9998		0.9032
584 Pb	1.0000		0.9030
560	1.0061		
540	1.0118		
532	1.0142		
510	1.0215	6.553	
465	1.0395	6.282	
415	1.0657	5.978	
370	1.0976	5.702	
302	1.1689	5.268	
261	1.2329	5.024	
222	1.3206	4.765	
124	1.7959	4.158	
101	2.0418	4.007	
83	2.3115	3.898	
68	2.6352	3.802	

(1) Relative Volume: V/Vsat is barrels at indicated pressure per barrel at saturation pressure. Data below bubble point smoothed by application of "Y" curve.

(2) Y Function: $\frac{(Psat-P)}{(Pabs)([V/Vsat]-1)}$

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COMPRESSIBILITY OF RESERVOIR FLUID AT 110°F.

From 5000 psig to 4000 psig = 3.45 x 10^{-6} V/V/psi

From 4000 psig to 3000 psig = 3.74 x 10^{-6} V/V/psi

From 3000 psig to 2000 psig = 4.13 x 10^{-6} V/V/psi

From 2000 psig to 1000 psig = 4.81 x 10^{-6} V/V/psi

From 1000 psig to 700 psig = 5.34 x 10^{-6} V/V/psi

From 700 psig to 584 psig = 6.03 x 10^{-6} V/V/psi

File RFL 1016

Well Phoenix No.1

VISCOSITY DATA AT 110°F.

Pressure, Psig		Oil Viscosity, Centipoise
5000		53.08
4000		46.02
3000		39.31
2000		33.44
1800	P_r	32.45
1000		28.53
600		26.41
584	P_b	26.34
500		26.96
400		27.74
340		28.28
280		28.90
245		29.35
190		30.29
135		31.69
100		33.04
60		35.38
0		43.21

Gravity of residual oil = 20.6 °API @ 60°F.

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SEPARATOR TESTS OF RESERVOIR FLUID SAMPLE

Separator Pressure, Psig	Separator Temperature °F.	Gas/Oil Ratio (1)	Gas/Oil Ratio (2)	Stock Tank Oil Gravity °API @ 60°F.	Formation Volume Factor Bofb (3)	Separator Volume Factor (4)	Specific Gravity of Flashed Gas
50	69	49	49			1.009	0.689*
to							
0	69	10	10	20.6	1.040	1.003	0.996
			R_{sfb} = 59				

* Collected and analyzed in the laboratory.

(1) Cubic feet of gas at 15.025 psia and 60°F. per barrel of oil at indicated pressure and temperature.

(2) Cubic feet of gas at 15.025 psia and 60°F. per barrel of stock tank oil at 60°F.

(3) Barrels of oil at 584 psig and 110°F. per barrel of stock tank oil at 60°F.

(4) Barrels of oil at indicated pressure and temperature per barrel of stock tank oil at 60°F.

HYDROCARBON ANALYSIS OF SEPARATOR TEST GAS AT 50 PSIG AND 68°F.

COMPONENT	MOL PERCENT	GPM
Hydrogen	0.76	
Hydrogen Sulfide	Nil	
Carbon Monoxide	4.53	
Carbon Dioxide	0.03	
Nitrogen	6.42	
Methane	79.48	
Ethane	3.75	1.023
Propane	2.67	0.750
iso-Butane	0.63	0.210
n-Butane	0.68	0.219
iso-Pentane	0.32	0.119
n-Pentane	0.20	0.074
Hexanes	0.20	0.079
Heptanes plus	0.33	0.149
	100.00	2.623

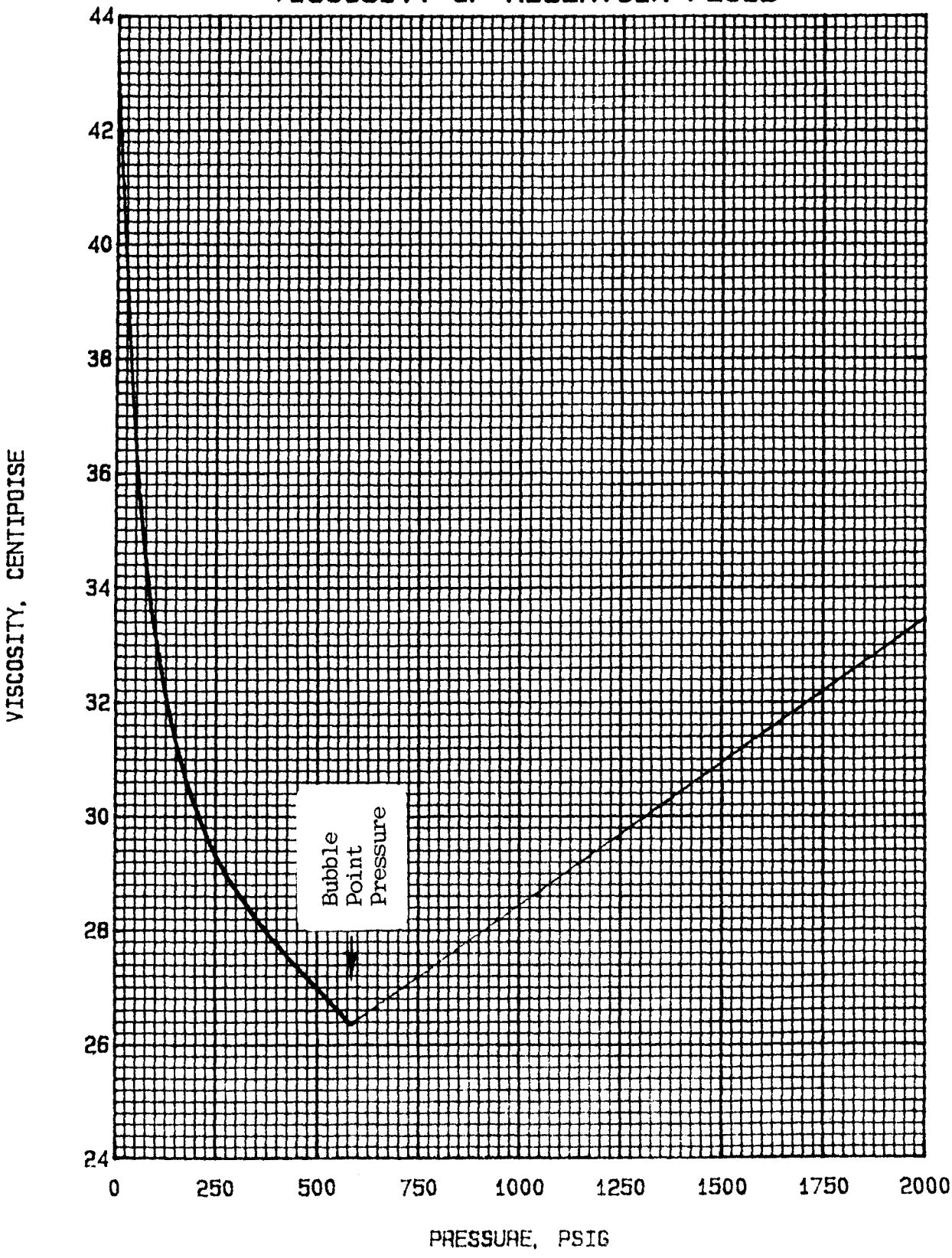
Calculated gas gravity= 0.689

Calculated Gross Heating Value= 1068 BTU per cubic foot of dry gas
@ 15.025 psia and 60 °F.

PROPERTIES OF CRUDE OIL

Sample	Paraffins wt%	Asphaltenes wt%	Pour Point °F.	API at 60°F.
12 DST 3	3.13	3.06	-45	20.2
14 DST 3	4.52	3.10	-45	20.3
16 DST 3	4.03	3.22	-40	20.3
19 DST 3	3.25	3.19	-40	20.4

VISCOSITY OF RESERVOIR FLUID



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Tenneco Oil Company
1100 Louisiana
Houston, TX

Attn:

Mineral Pattern

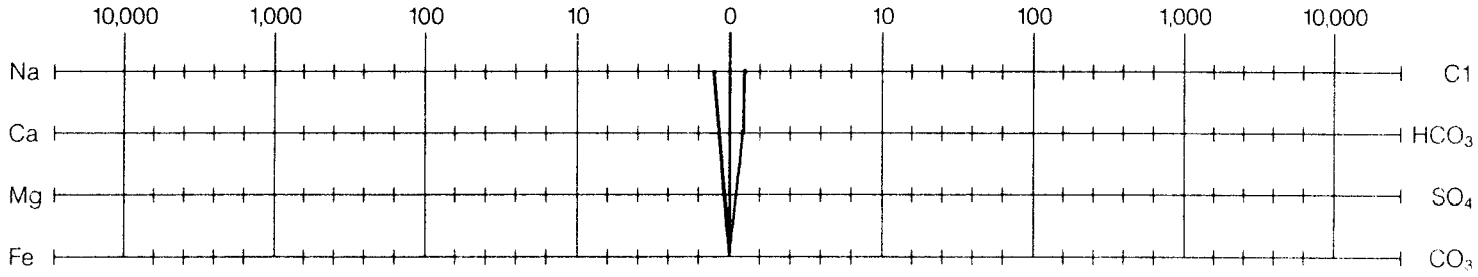
February 5, 1987

Invoice No.

Laboratory No.: 8711148

Date Received: 01/19/87

Sample Identification: Phoenix #1; Sample # 1



SCALE (Meq per liter)

	meq/l	mg/l
Anions		
Chloride	1	20
Sulfate	0	5
Carbonate	0	0
Bicarbonate	1	36
Cations		
Sodium *	1	22
Calcium	0	4
Magnesium	0	1
Iron	0	1
Total Dissolved Solids (Calculated)		100
pH	7.7	
Resistivity, ohm-M at Deg.F.	>10.0	
Specific Gravity at 68 Deg.F.	1.000	

* Sodium is calculated and includes Potassium.

Tenneco Oil Company
ATTN::

Laboratory No: 8711148 - Phoenix #1; Sample # 1

Stiff & Davis Stability Index:

-1.43 at 85°F.
-0.48 at 195°F.

A positive number is an indication of a tendency to form scale, while a negative number indicates the possibility of corrosion.

Tim Davis
Supervisor

vw

Litton
Core Lab

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Tenneco Oil Company
1100 Louisiana
Houston, TX

Attn:

Invoice No.

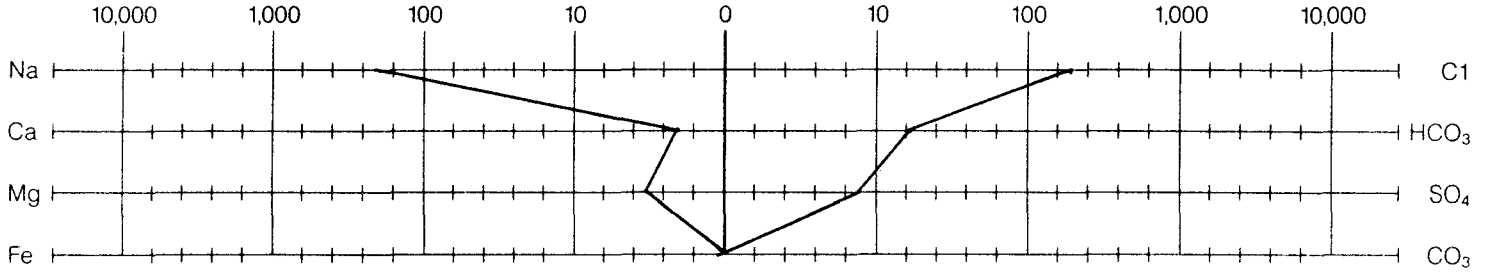
Mineral Pattern

February 5, 1987

Laboratory No.: 8711148

Date Received: 01/19/87

Sample Identification: Phoenix #1; Sample # 24



SCALE (Meq per liter)

	meq/l	mg/l
Anions		
Chloride	296	10,500
Sulfate	9	436
Carbonate	0	0
Bicarbonate	21	1,262
Cations		
Sodium *	318	7,300
Calcium	3	63
Magnesium	5	63
Iron	0	0
Total Dissolved Solids (Calculated)		19,600
pH	7.8	
Resistivity, ohm-M at Deg.F.	0.30	
Specific Gravity at 68 Deg.F.	1.028	

* Sodium is calculated and includes Potassium.

Laboratory No: 8711148 - Phoenix #1; Sample # 24

Stiff & Davis Stability Index:

+0.50 at 85°F.
+2.08 at 195°F.

A positive number is an indication of a tendency to form scale, while a negative number indicates the possibility of corrosion.

Tim Davis
Supervisor

vw

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1100 Louisiana
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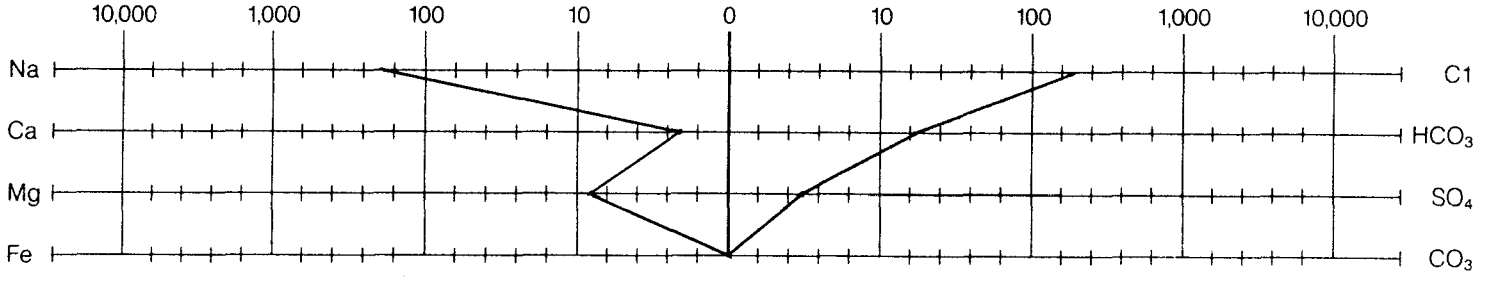
Mineral Pattern

February 5, 1987

Laboratory No.: 8711148

Date Received: 01/19/87

Sample Identification: Phoenix #1; Sample # 29



SCALE (Meq per liter)

	meq/l	mg/l
Anions		
Chloride	252	9,000
Sulfate	5	235
Carbonate	0	0
Bicarbonate	21	1,277
Cations		
Sodium *	266	6,100
Calcium	3	66
Magnesium	9	110
Iron	0	8
Total Dissolved Solids (Calculated)		16,800
pH	7.80	
Resistivity, ohm-M at Deg.F.	0.33	
Specific Gravity at 68 Deg.F.	1.012	

* Sodium is calculated and includes Potassium.

Tenneco Oil Company
ATTN::

Laboratory No: 8711148 - Phoenix #1; Sample # 29

Stiff & Davis Stability Index:

+0.54 at 85°F.
+2.12 at 195°F.

A positive number is an indication of a tendency to form scale, while a negative number indicates the possibility of corrosion.

Tim Davis
Supervisor

vw

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1100 Louisiana
Houston, TX

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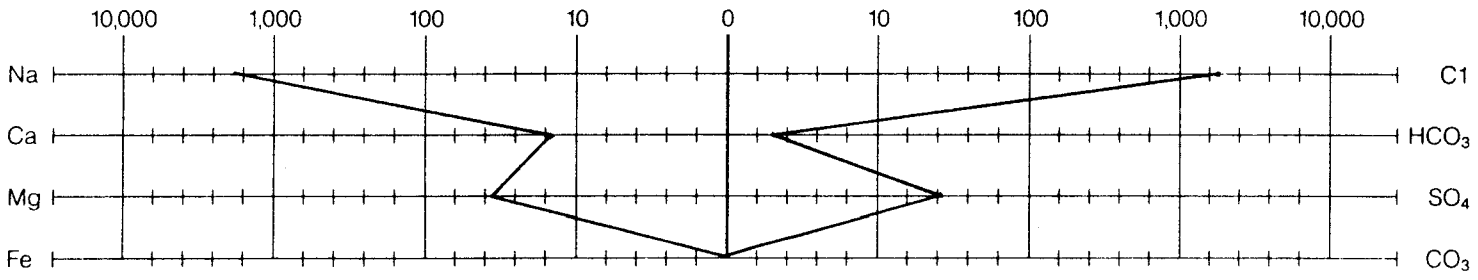
Attn:

Invoice No.

Laboratory No.: **8711148**

Date Received: **01/19/87**

Sample Identification: **Phoenix #1; Sample D**



SCALE (Meq per liter)

	meq/l	mg/l
Anions		
Chloride	2,457	87,100
Sulfate	41	1,966
Carbonate	0	0
Bicarbonate	3	175
Cations		
Sodium *	2,425	55,800
Calcium	19	380
Magnesium	56	680
Iron	1	27
Total Dissolved Solids (Calculated)		146,100
pH	7.3	
Resistivity, ohm-M at Deg.F.	0.06	
Specific Gravity at 68 Deg.F.	1.099	

* Sodium is calculated and includes Potassium.

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Mineral Pattern

February 5, 1987

Tenneco Oil Company
1100 Louisiana
Houston, TX

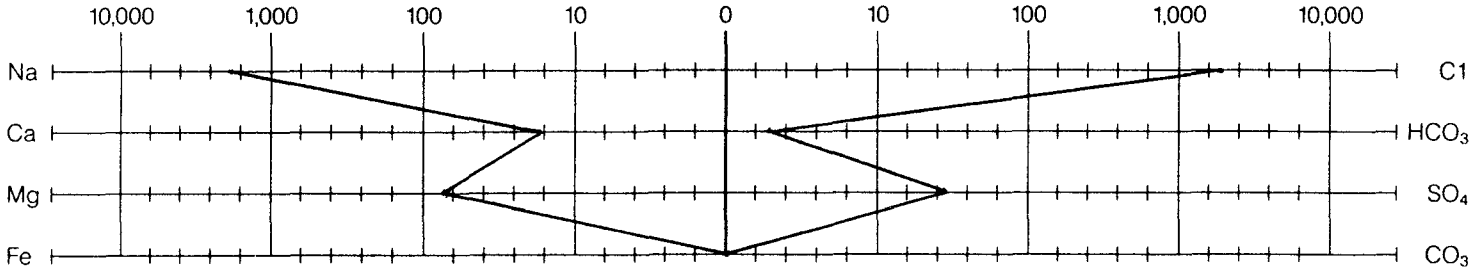
Attn:

Invoice No.

Laboratory No.: 8711148

Date Received: 01/19/87

Sample Identification: Phoenix #1; Sample # 3



SCALE (Meq per liter)

	meq/l	mg/l
Anions		
Chloride	2,666	94,500
Sulfate	43	2,085
Carbonate	0	0
Bicarbonate	3	170
Cations		
Sodium *	2,606	59,900
Calcium	21	430
Magnesium	85	1,030
Iron	0	8
Total Dissolved Solids (Calculated)		158,100
pH	7.5	
Resistivity, ohm-M at Deg.F.	0.055	
Specific Gravity at 68 Deg.F.	1.051	

* Sodium is calculated and includes Potassium.

Laboratory No: 8711148 - Phoenix #1; Sample # 3

Stiff & Davis Stability Index:

+0.18 at 85°F.
+2.10 at 195°F.

A positive number is an indication of a tendency to form scale, while a negative number indicates the possibility of corrosion.

Tim Davis
Supervisor

vw

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1100 Louisiana
Houston, TX

Mineral Pattern

February 5, 1987

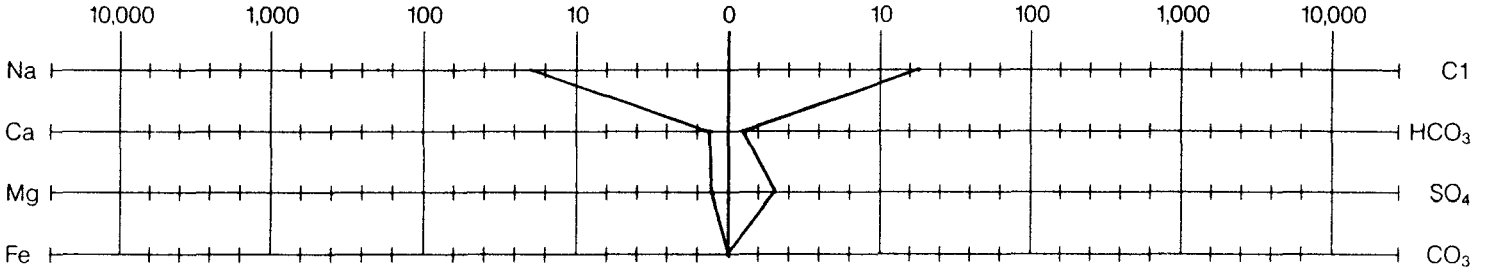
Attn:

Invoice No.

Laboratory No.: 8711148

Date Received: 01/19/87

Sample Identification: Phoenix #1; Sample A



SCALE (Meq per liter)

	meq/l	mg/l
Anions		
Chloride	24	863
Sulfate	3	154
Carbonate	0	0
Bicarbonate	1	88
Cations		
Sodium *	27	620
Calcium	1	12
Magnesium	1	16
Iron	0	3
Total Dissolved Solids (Calculated)		1,800
pH	6.9	
Resistivity, ohm-M at Deg.F.	2.5	
Specific Gravity at 68 Deg.F.	1.000	

* Sodium is calculated and includes Potassium.

Laboratory No: 8711148 - Phoenix #1; Sample A

Stiff & Davis Stability Index:

-1.36 at 85°F.
-0.41 at 195°F.

A positive number is an indication of a tendency to form scale, while a negative number indicates the possibility of corrosion.

Tim Davis
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February 5, 1987

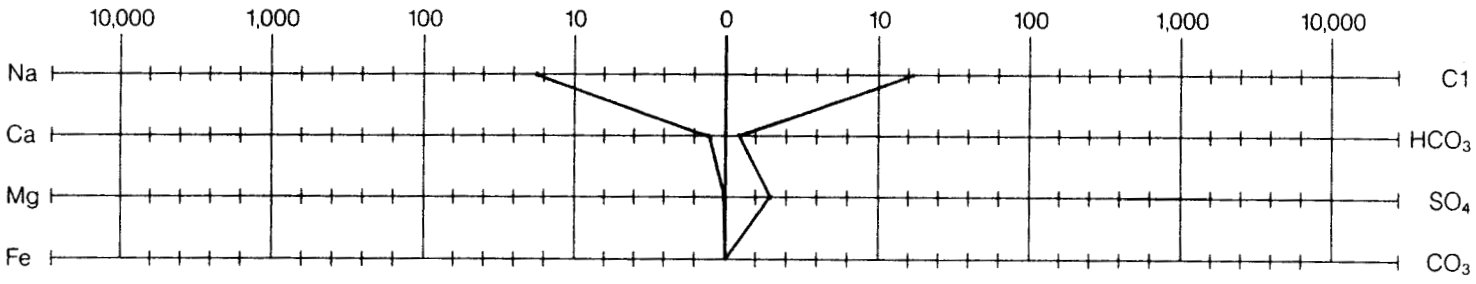
Attn:

Invoice No.

Laboratory No.: 8711148

Date Received: 01/19/87

Sample Identification: Phoenix #1; Sample # 9



SCALE (Meq per liter)

	meq/l	mg/l
Anions		
Chloride	21	750
Sulfate	3	136
Carbonate	0	0
Bicarbonate	1	21
Cations		
Sodium *	23	520
Calcium	1	24
Magnesium	0	3
Iron	0	8
Total Dissolved Solids (Calculated)		1,500
pH	8.0	
Resistivity, ohm-M at Deg.F.	5.0	
Specific Gravity at 68 Deg.F.	1.001	

* Sodium is calculated and includes Potassium.

Laboratory No: 8711148 - Phoenix #1; Sample # 9

Stiff & Davis Stability Index:

-0.59 at 85°F.
+0.36 at 195°F.

A positive number is an indication of a tendency to form scale, while a negative number indicates the possibility of corrosion.

Tim Davis
Supervisor

vw

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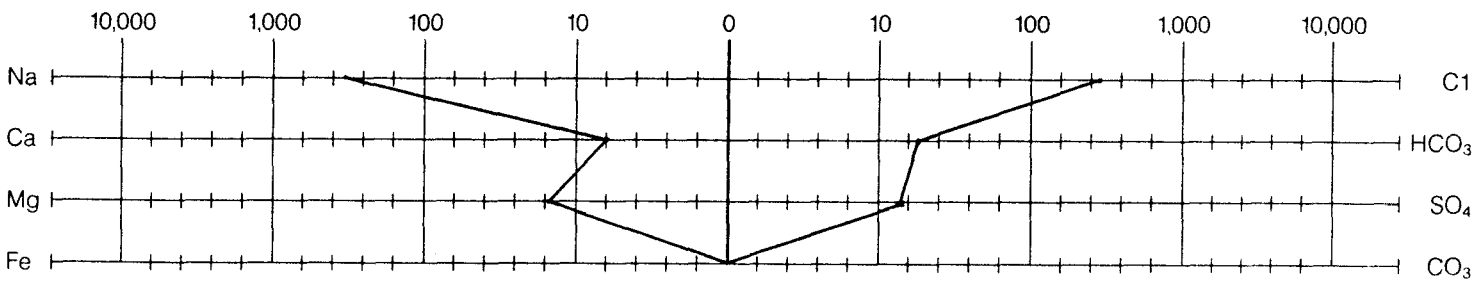
Attn:

Invoice No.

Laboratory No.: 8711148

Date Received: 01/19/87

Sample Identification: Phoenix #1; Sample # 18



SCALE (Meq per liter)

	meq/l	mg/l
Anions		
Chloride	437	15,500
Sulfate	17	822
Carbonate	0	0
Bicarbonate	23	1,432
Cations		
Sodium *	449	10,300
Calcium	8	170
Magnesium	19	230
Iron	1	37
Total Dissolved Solids (Calculated)		28,500
pH	7.7	
Resistivity, ohm-M at Deg.F.	0.21	
Specific Gravity at 68 Deg.F.	1.020	

* Sodium is calculated and includes Potassium.

Laboratory No: 8711148 - Phoenix #1; Sample # 18

Stiff & Davis Stability Index:

+0.67 at 85°F.
+2.38 at 195°F.

A positive number is an indication of a tendency to form scale, while a negative number indicates the possibility of corrosion.

Tim Davis
Supervisor

vw