



OILFIELD RESEARCH LABORATORIES

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Chanute, Kansas

October 18, 1965

Union Gas System, Inc.
P.O. Box 463
Independence, Kansas

Attn: Mr. Tom Lee

Gentlemen:

Enclosed herewith is the report of the analysis of the Rotary core taken from the Leffingwell Lease, Well No. 16, Elk County, Kansas, and submitted to our laboratory on October 9, 1965.

Your business is greatly appreciated.

Very truly yours,

OILFIELD RESEARCH LABORATORIES

Benjamin R. Pearman
Benjamin R. Pearman

BRP:rf

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Oilfield Research Laboratories

GENERAL INFORMATION & SUMMARY

Company Union Gas System, Inc. Lease Leffingwell Well No. 16

Location SW

Section 14 Twp. 31S Rge. 10E County Elk State Kansas

Name of Formation - - - - - Kansas City

Top of Core - - - - - 1353.0

Bottom of Core - - - - - 1376.4

Top of Lime - - (Analyzed) - - - - - 1357.6

Bottom of Lime - - (Analyzed) - - - - - 1376.4

Total Feet of Permeable Lime - - - - - 12.0

Total Feet of Floodable Lime - - - - - 9.0

Distribution of Permeable Lime
Permeability Range
Millidarcys

Feet

Cum. Ft.

	Feet	Cum. Ft.
0 - 4	4.0	4.0
11 - 35	4.0	8.0
50 - 110	3.0	11.0
110 & above	1.0	12.0

Average Permeability Millidarcys - - - - - 282.5

Average Percent Porosity - - - - - 7.4

Average Percent Oil Saturation - - - - - 33.1

Average Percent Water Saturation - - - - - 49.6

Average Oil Content, Bbls./A. Ft. - - - - - 184.

Total Oil Content, Bbls./Acre - - - - - 3,456.

Average Percent Oil Recovery by Laboratory Flooding Tests - - - - - 9.9

Average Oil Recovery by Laboratory Flooding Tests, Bbls./A. Ft. - - - - - 78.

Total Oil Recovery by Laboratory Flooding Tests, Bbls./Acre - - - - - 699.

Total Calculated Oil Recovery, Bbls./Acre - (See Conclusions) - - - - -

Packer Setting, Feet - - - - -

Viscosity, Centipoises @ - - - - -

A. P. I. Gravity, degrees @ 60 °F - - - - -

Elevation, Feet - - - - -

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GENERAL INFORMATION & SUMMARY

Company Union Gas System, Inc. Lease Leffingwell Well No. 16

Location SW

Section 14 Twp. 31S Rge. 10E County Elk State Kansas

Name of Formation	Oswego
Top of Core	1638.0
Bottom of Core	1660.5
Top of Lime	1638.6
Bottom of Lime	1659.6
Total Feet of Permeable Lime	17.0
Total Feet of Floodable Lime	10.7

Distribution of Permeable Lime

Permeability Range Millidarcys	Feet	Cum. Ft.
0 - 5	5.3	5.3
10 - 50	4.0	9.3
50 - 100	3.7	13.0
100 - 1000	3.0	16.0
1000 & above	1.0	17.0

Average Permeability Millidarcys	266.2
Average Percent Porosity	12.7
Average Percent Oil Saturation	42.2
Average Percent Water Saturation	38.4
Average Oil Content, Bbls./A. Ft.	429.
Total Oil Content, Bbls./Acre	9,003.
Average Percent Oil Recovery by Laboratory Flooding Tests	13.3
Average Oil Recovery by Laboratory Flooding Tests, Bbls./A. Ft.	167.
Total Oil Recovery by Laboratory Flooding Tests, Bbls./Acre	1,789.
Total Calculated Oil Recovery, Bbls./Acre	(See Conclusions)
Packer Setting, Feet	
Viscosity, Centipoises @	
A. P. I. Gravity, degrees @ 60 °F	
Elevation, Feet	

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GENERAL INFORMATION & SUMMARY

Company Union Gas System, Inc. Lease Leffingwell Well No. 16

Location SW

Section 14 Twp. 31S Rge. 10E County Elk State Kansas

Name of Formation	Mississippi
Top of Core	1971.0
Bottom of Core	1996.0
Top of Lime	1971.0
Bottom of Lime	1996.0
Total Feet of Permeable Lime	13.2
Total Feet of Floodable Lime	3.0

Distribution of Permeable Lime:

Permeability Range Millidarcys	Feet	Cum. Ft.
0 - 1	4.0	4.0
1 - 5	8.6	12.6
5 & above	0.6	13.2

Average Permeability Millidarcys	2.8
Average Percent Porosity	8.2
Average Percent Oil Saturation	44.4
Average Percent Water Saturation	18.0
Average Oil Content, Bbls./A. Ft.	272.
Total Oil Content, Bbls./Acre	5,691.
Average Percent Oil Recovery by Laboratory Flooding Tests	7.7
Average Oil Recovery by Laboratory Flooding Tests, Bbls./A. Ft.	65.
Total Oil Recovery by Laboratory Flooding Tests, Bbls./Acre	195.
Total Calculated Oil Recovery, Bbls./Acre (Primary)	1,980.
Packer Setting, Feet	
Viscosity, Centipoises @	
A. P. I. Gravity, degrees @ 60 °F	
Elevation, Feet	

Fresh water mud was used as the circulating fluid while taking these cores. The cores were sampled and the samples sealed in cans by a representative of Oilfield Research Laboratories. The well was drilled in non-virgin territory.

FORMATION CORED

The detailed log of the formation cored is as follows:

<u>Depth Interval,</u> <u>Feet</u>	<u>Description</u>
---------------------------------------	--------------------

-KANSAS CITY LIME-

1353.0 - 1357.6 - Gray shaly limestone.

1357.6 - 1376.4 - Grayish brown, vuggy, slightly sandy limestone.

-OSWEGO LIME-

1638.0 - 1639.6 - Gray, vuggy, slightly sandy limestone.

1639.6 - 1641.6 - Brownish gray, vuggy, slightly sandy limestone.

1641.6 - 1645.0 - Brown, sandy, vuggy, slightly cherty limestone.

1645.0 - 1646.3 - Gray, shaly, slightly sandy, slightly cherty limestone.

1646.3 - 1659.6 - Brown, sandy, vuggy limestone.

1659.6 - 1660.5 - Gray limestone.

-MISSISSIPPI LIME-

1971.0 - 1980.5 - Brown, crystalline, dolomitic limestone.

1980.5 - 1982.6 - Gray shaly limestone.

1982.6 - 1985.0 - Brown, crystalline, dolomitic limestone.

1985.0 - 1986.0 - Gray shaly limestone.

1986.0 - 1987.0 - Brown, crystalline, dolomitic limestone.

1987.0 - 1988.0 - Gray shaly limestone.

1988.0 - 1996.0 - Brown, crystalline, dolomitic limestone.

Coring was started at a depth of 1353.0 feet in the Kansas City and completed at 1996.0 feet in the Mississippi formation.

PERMEABILITY

The weighted average permeability of the Kansas City, Oswego and Mississippi sections is 282.5, 266.2 and 2.8 millidarcys respectively (See Table III). By observing the data given on the coregraph, it is noticeable that the zones have irregular permeability profiles.

PERCENT SATURATION & OIL CONTENT

The weighted average percent oil saturation of the upper, middle and lower sections is 33.1, 42.2 and 44.4 respectively. The weighted average percent water saturation of the upper, middle and lower sections is 49.6, 38.4 and 18.0 respectively (See Table III). These give overall weighted average total fluid saturations of 82.7, 80.6 and 62.4 percent respectively. These total fluid saturations indicate that some flushing probably occurred in the Kansas City and Oswego cores during coring operations.

The weighted average oil content of the upper, middle and lower sections is 184, 429 and 272 barrels per acre foot respectively. The total oil content, as shown by these cores, is 3,456, 9,003 and 5,691 barrels per acre respectively (See Table III).

LABORATORY FLOODING TESTS

The Kansas City and Oswego cores responded to laboratory flooding tests, as a total recovery of 699 and 1,789 barrels of oil per acre was obtained from 9.0 and 10.7 feet of sand respectively. The weighted average

effective permeabilities of the three cores are 7.03, 5.24 and 0.800 millidarcys, while the average initial fluid production pressures are 27.8, 20.0 and 40.0 pounds per square inch (See Table V).

By observing the data given in Table IV, you will note that approximately 50 percent of the Kansas City and Oswego cores are permeable to water and recovered oil on flood-pot tests.

CONCLUSION

Based on the results of the laboratory tests, the primary history submitted to us and the assumption that these cores are representative of the formations, it would appear that water-flooding operations in these zones would not be commercial successes. The primary recoveries for the Kansas City and Oswego sections appear to be 93 percent and 27 percent of the porosities respectively, indicating that a water-flood would recover very little additional oil.

However, this well should make a primary producer, depending of course, on how much the reservoir pressure has been depleted. Assuming this to be an average Kansas City and Oswego well, the primary reserves are approximately 5,200 barrels per acre.

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RESULTS OF SATURATION & PERMEABILITY TESTS

TABLE 1-B

Company Union Gas System, Inc. Lease Leffingwell Well No. 16

Sample No.	Depth, Feet	Effective Porosity Percent	Percent Saturation		Oil Content Bbls. / A Ft.	Perm., Mill.	Feet of Sand		Total Oil Content	Perm. Capacity Ft. X md.
			Oil	Water			Ft.	Cum. Ft.		
1	1358.1	3.6	41	50	115	Imp.	1.0	1.0	115	0.00
2	1359.1	3.0	26	67	60	Imp.	1.0	2.0	60	0.00
3	1360.1	4.0	28	42	87	Imp.	1.0	3.0	87	0.00
4	1361.1	8.5	25	44	165	35.	1.0	4.0	165	35.00
5	1362.1	13.2	29	47	297	3064.	1.0	5.0	297	3064.00
6	1363.1	12.9	42	55	420	106.	1.0	6.0	420	106.00
7	1364.1	3.9	36	45	109	31.	1.0	7.0	109	31.00
8	1365.1	3.7	52	38	149	Imp.	1.0	8.0	149	0.00
9	1366.1	9.2	35	23	250	2.6	1.0	9.0	250	2.60
10	1367.1	7.8	33	48	200	13.	1.0	10.0	200	13.00
11	1368.1	7.8	51	40	308	11.	1.0	11.0	308	11.00
12	1369.1	7.5	34	56	198	2.0	1.0	12.0	198	2.00
13	1370.1	7.3	27	65	153	61.	1.0	13.0	153	61.00
14	1371.1	12.1	18	50	169	0.70	1.0	14.0	169	0.70
15	1372.1	10.4	31	63	250	57.	1.0	15.0	250	57.00
16	1373.1	9.0	17	50	119	Imp.	1.0	16.0	119	0.00
17	1374.1	4.9	32	60	122	3.9	1.0	17.0	122	3.90
18	1375.1	5.7	37	50	164	Imp.	1.0	18.0	164	0.00
19	1376.1	5.4	36	50	151	Imp.	0.8	18.8	121	0.00
							Total		3,456	

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RESULTS OF SATURATION & PERMEABILITY TESTS

TABLE 1-B

Company Union Gas System, Inc. Lease Leffingwell Well No. 16

Sample No.	Depth, Feet	Effective Porosity Percent	Percent Saturation			Oil Content Bbls. / A Ft.	Perm., Mill.	Feet of Sand		Total Oil Content	Perm. Capacity Ft. X md.
			Oil	Water	Total			Ft.	Cum. Ft.		
1	1639.1	10.5	13	81	94	106	Imp.	1.0	1.0	106	0.00
2	1640.1	5.5	42	44	86	179	0.87	1.0	2.0	179	0.87
3	1641.1	5.0	24	68	92	93	Imp.	1.0	3.0	93	0.00
4	1642.1	12.0	56	26	82	521	2.8	1.0	4.0	521	2.80
5	1643.1	21.6	53	34	87	886	108.	1.0	5.0	886	108.00
6	1644.1	16.4	34	32	66	432	63.	1.4	6.4	606	88.20
7	1645.1	9.0	54	14	68	377	3.9	0.6	7.0	226	2.34
8	1646.1	10.0	38	37	75	294	4.5	0.7	7.7	206	3.15
9	1647.1	18.3	43	34	77	610	76.	1.3	9.0	793	98.80
10	1648.1	14.0	14	59	73	152	46.	1.0	10.0	152	46.00
11	1649.1	14.4	56	38	94	626	21.	1.0	11.0	626	21.00
12	1650.1	16.6	53	32	85	685	184.	1.0	12.0	685	184.00
13	1651.1	17.4	53	45	98	718	1.8	1.0	13.0	718	1.80
14	1652.1	14.5	40	40	80	450	13.	1.0	14.0	450	13.00
15	1653.1	8.4	16	20	36	104	51.	1.0	15.0	104	51.00
16	1654.1	18.9	41	54	95	603	2920.	1.0	16.0	603	2920.00
17	1655.1	12.1	33	55	88	310	936.	1.0	17.0	310	936.00
18	1656.1	5.3	39	33	72	161	Imp.	1.0	18.0	161	0.00
19	1657.1	7.0	78	15	93	423	Imp.	1.0	19.0	423	0.00
20	1658.1	15.1	66	32	98	775	44.	1.0	20.0	775	44.00
21	1659.1	10.2	48	9	57	380	4.8	1.0	21.0	380	4.80
								Total	-----	9,003	

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RESULTS OF SATURATION & PERMEABILITY TESTS

TABLE I-B

Company Union Gas System, Inc. Lease Leffingwell Well No. 16

Sample No.	Depth, Feet	Effective Porosity Percent	Percent Saturation			Oil Content Bbls. / A Ft.	Perm., Mill.	Feet of Sand		Total Oil Content	Perm. Capacity Ft. X md.
			Oil	Water	Total			Ft.	Cum. Ft.		
1	1971.1	10.4	62	6	68	500	15.	0.6	0.6	300	9.00
2	1972.1	11.2	38	10	48	330	4.2	1.0	1.6	330	4.20
3	1973.1	11.8	32	11	43	293	3.5	1.0	2.6	293	3.50
4	1974.1	9.1	37	17	54	261	3.4	1.0	3.6	261	3.40
5	1975.1	9.9	36	21	57	276	1.7	1.0	4.6	276	1.70
6	1976.1	10.7	48	13	61	398	0.40	1.0	5.6	398	0.40
7	1977.1	8.2	13	12	25	83	4.3	1.0	6.6	83	4.30
8	1978.1	10.7	48	47	95	398	3.7	1.0	7.6	398	3.70
9	1979.1	5.1	80	14	94	316	3.2	1.0	8.6	316	3.20
10	1980.1	6.0	38	31	69	177	Imp.	0.9	9.5	159	0.00
11	1983.1	6.2	33	20	53	159	0.92	1.0	10.5	159	0.92
12	1984.1	7.6	30	25	55	177	Imp.	1.4	11.9	248	0.00
13	1986.1	4.1	69	9	78	219	1.8	1.0	12.9	219	1.80
14	1988.2	5.0	53	13	66	206	1.2	0.6	13.5	124	0.72
15	1989.1	7.8	49	5	54	296	Imp.	1.0	14.5	296	0.00
16	1990.1	9.4	48	10	58	350	Imp.	1.0	15.5	350	0.00
17	1991.1	8.1	37	16	53	232	0.17	1.0	16.5	232	0.17
18	1992.1	7.0	42	25	67	228	Imp.	1.0	17.5	228	0.00
19	1993.1	7.2	52	14	66	290	Imp.	1.0	18.5	290	0.00
20	1994.1	9.3	49	24	73	353	0.24	1.0	19.5	353	0.24
21	1995.1	6.7	52	25	77	270	Imp.	1.4	20.9	378	0.00
								Total	-----	5,691	

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RESULTS OF LABORATORY FLOODING TESTS

TABLE IV

Company Union Gas System, Inc. Lease Leffingwell Well No. 16

Sample No.	Depth, Feet	Effective Porosity Percent	Original Oil Saturation		Oil Recovery		Residual Saturation		Volume of Water Recovered cu ³	Interfacial Tension mDyne/cm	Initial Fluid Production Pressure Lbs./Sq./In.
			%	Bbls./A. Ft.	%	Bbls./A. Ft.	% Oil	Bbls./A. Ft.			
1	1358.1	3.4	41	108	0	0	41	108	0	Imp.	-
2	1359.1	3.1	28	67	0	0	28	67	0	Imp.	-
3	1360.1	3.9	28	85	0	0	28	85	0	Imp.	-
4	1361.1	8.0	25	155	4	25	21	130	30	0.875	25
5	1362.1	13.5	29	304	8	84	21	220	382	27.00	20
6	1363.1	13.4	42	436	22	228	20	208	316	23.20	20
7	1364.1	4.2	36	117	8	26	28	91	6	0.100	50
8	1365.1	3.6	52	145	0	0	52	145	0	Imp.	-
9	1366.1	9.2	36	257	0	0	36	257	0	Imp.	-
10	1367.1	8.3	33	212	5	32	28	180	17	0.500	40
11	1368.1	8.2	51	324	22	140	29	184	212	5.60	20
12	1369.1	7.6	34	200	0	0	34	200	0	Imp.	-
13	1370.1	7.8	27	163	3	18	24	145	18	0.380	30
14	1371.1	12.2	18	170	3	28	15	142	199	4.00	20
15	1372.1	10.9	31	262	14	118	17	144	67	1.70	25
16	1373.1	9.5	17	125	0	0	17	125	24	0.625	30
17	1374.1	4.6	33	118	0	0	33	118	0	Imp.	-
18	1375.1	6.1	36	170	0	0	36	170	0	Imp.	-
19	1376.1	5.5	37	158	0	0	37	158	0	Imp.	-

Notes: cc—cubic centimeter.

a.—Volume of water recovered at the time of maximum oil recovery.

cc.—Determined by passing water through sample which still contains residual oil.

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RESULTS OF LABORATORY FLOODING TESTS

TABLE IV

Sample No.	Depth, Feet	Effective Porosity Percent	Original Oil Saturation		Oil Recovery		Residual Saturation		Volume of Water Recovered cc ^a	Effective Permeability Millidarcys ^b	Initial Fluid Production Pressure Lbs./Sq./In.
			%	Bbls./A. Ft.	%	Bbls./A. Ft.	% Oil	% Water			
1	1639.1	10.7	14	116	0	0	14	82	0	Imp.	-
2	1640.1	5.5	43	183	0	0	43	43	0	Imp.	-
3	1641.1	5.3	24	99	0	0	24	70	0	Imp.	-
4	1642.1	11.7	57	517	0	0	57	28	0	Imp.	-
5	1643.1	21.2	53	870	25	411	28	58	170	32.50	10
6	1644.1	16.0	34	421	7	87	27	65	126	2.10	20
7	1645.1	8.7	55	371	0	0	55	16	0	Imp.	-
8	1646.1	10.0	40	310	0	0	40	36	0	Imp.	-
9	1647.1	18.0	43	600	8	112	35	62	126	2.80	10
10	1648.1	14.0	14	152	0	0	14	60	0	Imp.	-
11	1649.1	14.2	56	616	12	132	44	50	26	0.750	30
12	1650.1	16.4	53	674	9	114	44	54	14	0.376	30
13	1651.1	17.9	53	735	23	319	30	68	294	2.50	10
14	1652.1	14.6	40	452	0	0	40	42	0	Imp.	-
15	1653.1	8.4	15	98	0	0	15	22	0	Imp.	-
16	1654.1	19.4	41	616	17	256	24	74	270	12.08	10
17	1655.1	12.0	33	307	8	74	25	63	77	0.900	10
18	1656.1	5.3	40	164	0	0	40	36	0	Imp.	-
19	1657.1	7.4	78	447	19	109	59	35	10	0.194	30
20	1658.1	15.2	66	778	9	106	57	42	9	0.133	40
21	1659.1	10.0	50	388	0	0	50	43	0	Imp.	-

Notes: cc—cubic centimeter.

^a—Volume of water recovered at the time of maximum oil recovery.

^b—Determined by passing water through sample which still contains residual oil.

Company Union Gas System, Inc.

Lease

Leffingwell

Well No. 16

Oilfield Research Laboratories

RESULTS OF LABORATORY FLOODING TESTS

TABLE IV

Company Union Gas System, Inc. Lease Leffingwell Well No. 16

Sample No.	Depth, Feet	Effective Permeability Percent	Original Oil Saturation		Oil Recovery		Residual Saturation		Volume of Water Recovered cc ^a	Effective Permeability Millidarcys ^b	Initial Fluid Production Pressure Lbs./Sq./In.
			%	Bbls./A. Ft.	%	Bbls./A. Ft.	% Oil	% Water			
1	1971.1	10.2	62	491	0	0	62	8	0	Imp.	-
2	1972.1	11.2	40	347	0	0	40	10	0	Imp.	-
3	1973.1	11.3	34	298	0	0	34	41	4	0.200	50
4	1974.1	9.3	37	267	0	0	37	26	3	0.100	50
5	1975.1	10.4	36	290	2	16	34	35	13	0.300	40
6	1976.1	11.2	48	417	14	122	34	42	72	1.90	30
7	1977.1	8.4	15	98	0	0	15	14	0	Imp.	-
8	1978.1	10.4	48	387	7	57	41	55	10	0.200	50
9	1979.1	5.1	78	308	0	0	78	17	0	Imp.	-
10	1980.1	6.0	39	182	0	0	39	33	0	Imp.	-
11	1983.1	6.3	33	161	0	0	33	24	0	Imp.	-
12	1984.1	7.7	30	179	0	0	30	26	0	Imp.	-
13	1986.1	4.0	70	217	0	0	70	12	0	Imp.	-
14	1988.1	5.0	55	213	0	0	55	13	0	Imp.	-
15	1989.1	8.1	48	302	0	0	48	7	0	Imp.	-
16	1990.1	9.4	48	350	0	0	48	11	0	Imp.	-
17	1991.1	7.9	39	238	0	0	39	18	0	Imp.	-
18	1992.1	7.0	46	250	0	0	46	26	0	Imp.	-
19	1993.1	7.0	52	282	0	0	52	15	0	Imp.	-
20	1994.1	9.0	51	356	0	0	51	24	0	Imp.	-
21	1995.1	7.0	52	282	0	0	52	24	0	Imp.	-

Notes: cc—cubic centimeter.

^a—Volume of water recovered at the time of maximum oil recovery.

^b—Determined by passing water through sample which still contains residual oil.

Oilfield Research Laboratories

SUMMARY OF LABORATORY FLOODING TESTS

TABLE V

Company	Lease	Leffingwell	Well No.
Union Gas System, Inc.	KANSAS CITY	OSWEGO	MISSISSIPPI
Depth Interval, Feet	1357.6 - 1376.4	1638.6 - 1659.6	1971.0 - 1996.0
Feet of Core Analyzed	9.0	10.7	3.0
Average Percent Porosity	9.6	15.8	10.7
Average Percent Original Oil Saturation	32.5	50.1	44.0
Average Percent Oil Recovery	9.9	13.3	7.7
Average Percent Residual Oil Saturation	22.6	36.8	36.3
Average Percent Residual Water Saturation	65.3	57.5	44.0
Average Percent Total Residual Fluid Saturation	87.9	94.3	80.3
Average Original Oil Content, Bbls./A. Ft.	239.	599.	365.
Average Oil Recovery, Bbls./A. Ft.	78.	167.	65.
Average Residual Oil Content, Bbls./A. Ft.	161.	432.	300.
Total Original Oil Content, Bbls./Acre	2,143.	6,414.	1,094.
Total Oil Recovery, Bbls./Acre	699.	1,789.	195.
Total Residual Oil Content, Bbls./Acre	1,444.	4,625.	899.
Average Effective Permeability, Millidarcys	7.03	5.24	0.800
Average Initial Fluid Production Pressure, p.s.i.	27.8	20.0	40.0

NOTE: Only those samples which recovered oil were used in calculating the above averages.