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## Microbial EOR Laboratory Studies and Application Results in Daqing Oilfield

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### Abstract

Microbe inoculation of Daqing crude samples in the laboratory reduced oil viscosity, indicating microbe effectiveness. Field application of the same strains of microbes resulted in a thousand-fold increase in both concentration and total number of microbes in the water produced from the reservoir. The data proves existence of active, thriving microbe colonies in the reservoir in a manner not previously reported, compatibility between the microbes and Daqing oil in the reservoir, and propagation in the reservoir. The microbe detection method is reviewed along with microbe growing details in four wells. Overall field results in twenty-five wells are described, proving microbial EOR (MEOR) is suitable for use in Daqing Oilfield.

### Introduction

Enhancing oil recovery by the application of microbes was first suggested in the 1940's<sup>1</sup>. Since then over the past fifty years progress has been made in this realm primarily in the laboratory. But there have been a few commercial field applications of microbial EOR<sup>2</sup>. In the mid and early 1990's, Brown reported on the results of large-scale, field application on 146 wells. This project was the first time that MEOR technology was applied profitably on a commercial scale.<sup>3,4</sup>

Following Mr. Brown's work, MEOR technology was further developed with updated generations of microbial products with increased concentrations, making the technology better suited for use globally.<sup>5</sup> Since August 1994 MEOR technology has been applied to Huabei, Xinjiang, Jilin, Zhongyuan, Shengli, Changqing, Liaohe, Tuha and Daqing Oil Fields in P. R. of China<sup>5</sup>. Good technical and economic results were achieved in many of these fields. Many reports on

these MEOR applications were internally circulated in P. R. of China, except Huabei and Xinjiang results were reported in a previous SPE paper<sup>6</sup>. Results of MEOR application in Daqing Oilfield are published here for the first time. Good MEOR incremental production and the increase in the number of living microbes in the produced water have the potential of turning MEOR technology development toward a new course.

Of major concern is that microbes, alive when injected, survive and propagate in the reservoir environment. The literature contains several reports on microbes living in reservoirs.

Portwood and Hiebert reported that aerobic microbes, biological catalyzer and inorganic nutrient were injected into ten oil production wells. Living microbes were counted for eight wells after MEOR treatments. Among these wells, only four were measured thoroughly. Proterozoic hydrocarbon-oxidizing microbes in the produced fluid increased on each well varying from 10 to 10<sup>8</sup> times<sup>7</sup>. But the result is suspect. The microbe treatment fluid consisted of seventy-three pounds of dried microbe powder with a concentration of 10<sup>12</sup> microbes/gram mixed with forty pounds of microbial catalyzer in eighty barrels of water. Most likely before injection the concentration increased by propagation (near 10<sup>12</sup>/ml). So the increased microbe population mentioned may have been from injected survivors, not from propagation in the reservoir. Lazar reported that in Rumania, after molasses injection, microbe concentration in produced water increased to 3.5x10<sup>9</sup>, 2.7x10<sup>8</sup>, 1.2x10<sup>8</sup> from 1.47x10<sup>6</sup>, 9.2x10<sup>6</sup>, 1.4x10<sup>6</sup> respectively. Incremental microbes were 10<sup>2</sup> to 10<sup>3</sup>, but these microbes survival depended on residual molasses in the produced fluid.<sup>7</sup> Both these applications are severely restricted commercially due to requiring nutrient injection.

Pelger reported one case of microbe injection without nutrient. Microbe concentration increased to 700 to 1200 cfu/ml from 300 to 900 cfu/ml measured by microscope (microbes concentration decreased to 700~800/ml from 900/ml in some wells), but three concerns exist:

1. Number of incremental microbes is very low, below one order of magnitude, only about -0.15 to 2.5 times the injected microbes.
2. Microscope counting cannot distinguish living from dead microbes.

3. The injected microbes concentration is  $0.8 \times 10^6$  to  $1.2 \times 10^6$  cfu/ml by microscope counting. About 15 liters of fluid were injected, so total numbers of the injected microbes were  $1.5 \times 10^{10}$ , but total numbers of produced microbes were  $4 \times 10^8$  (20 ton of oil at a 5% water cut with 400 cfu/ml average incremental microbes). The number of produced microbes was below that of injected microbes, so microbe growth in the reservoir is not proven.

On this project a more systematic approach to laboratory testing, field application and monitoring was followed to ensure clearly discernable results.

Mechanisms by which MEOR Microbes can improve oil recovery as reported in the literature are<sup>7,8</sup>:

1. Generating gases that increase reservoir pressure and reduce oil viscosity,
2. Generating acids that dissolve rock and improve absolute permeability,
3. Reducing permeability in channels thereby improving displacement conformance (With injected water microbes move into highly permeable channels and pores. Permeability is reduced with gas, metabolic products and aggregation of microbe body mass),
4. Altering wettability,
5. Producing bio-surfactants by metabolizing hydrocarbons that decrease interfacial tension, and
6. Reducing oil viscosity by degrading long-chain saturated hydrocarbons.

For Daqing reservoirs and the microbes used in this project, items 5 and 6 are considered the most significant mechanisms for residual oil reduction and production increase<sup>4,5,6</sup>.

The commercially available microbe products used in this project are mixtures of several strains of facultative anaerobic microbes for improving oil properties and recovery<sup>3,4,5</sup>. The microbes are 1 to 4 microns in length, and 0.1 to 0.3 microns in diameter. They are motile and can migrate into reservoir pores. Metabolic products are organic acids, ethanol and surfactants as well as decomposition of long-chain hydrocarbons into solvents. The products are mixed cultures of microbes that are able to metabolize hydrocarbons and produce beneficial byproducts.

The MEOR process is that microbes convert the reservoir into a bioreactor. Unmovable residual oil and water in the reservoir provide the media for microbe propagation and migration. No external nutrients are supplied.

### Laboratory Screening Test

From the screening test of a typical oil sample it was determined that Daqing oil reservoirs in general are suitable for the microbe growth. The next step was the testing of numerous samples from various wells and reservoirs.

Oil and water samples from 30 wells were tested to determine the reduction in viscosity caused by the microbes. Viscosity was reduced by more than twenty percent on all but four wells (wells 15-24, 15-233, 16-232 and 17-24 of Production Division 6). Table 1 lists the 25 wells on which inoculation tests were done, which tested effective and were chosen

for the pilot study. The microbes significantly reduced the average viscosity for all of these wells:

- 13 wells of Production Division 2 were reduced by 63.1%,
- 8 wells of Production Division 3 were reduced by 39.5%, and
- 4 wells of Production Division 6 were reduced by 43.7%.

The laboratory studies indicate that:

1. The microbes are effective at reducing oil viscosity which enhances the oil mobility by increasing short-chain hydrocarbons through degrading long-chain normal alkanes; and
2. The effective trend of viscosity reduction increases from North (Production Division 6) to South (Production Division 2).

### Microbe Concentrations in Produced Water

For effective MEOR field treating, the microbes are squeezed down hole into the near well-bore vicinity of the reservoir to facilitate better migration, colonization and propagation outward into the producing formation. The MEOR squeezes were performed down the casing-tubing annulus periodically with enough shut-in time after each treatment for microbes to become established and begin growing before resuming rod pumping. The treatments were approximately one month apart, with three days of shut-in time after the first treatment and one day after subsequent treatments.

Table 2 presents living microbes concentrations before and after MEOR for five treatments on 4 different wells in Production Division 6 of Daqing Oil Field. The microbe counting was done using the 5-tube dilution MPN method.<sup>10</sup> Before MEOR treating, corpuscle counting of living microbes was done with results similar to the baseline readings presented in Table 2.

Table 2 illustrates that living microbe concentrations increased a thousand-fold. Maximum microbe concentrations in the produced water at the wellhead were  $10^3$  to  $10^4$  cfu/ml above pre-MEOR levels, averaging more than 1000 for the four wells. The increase indicates favorable reservoir conditions for microbe growth and propagation. This excellent result which is indicative of a thriving microbe colony in the reservoir provides confirmation that sufficient microbes are active to reduce oil viscosity, resulting in higher oil flow rates and enhancing oil recovery.

Figure 1 and related tables show that:

1. The concentration of living microbes increased 1000 times in produced water.
2. The total number of living microbes increased over 1,000 times. The concentration in the microbe-laden treating water was  $10^4$  to  $10^5$  cfu/ml, but concentrations reached  $10^7$  in produced water. The number of microbes squeezed into the formation was calculated by multiplying the treatment volume by the microbe concentration. The number of produced living microbes was calculated similarly, based on the 24 tons

of produced fluid per hour at an average water cut of 90% over 46 days. The produced microbes totaled 1035 times more than the number squeezed into the reservoir.

In addition to the 1035 times incremental of living microbes produced from reservoir, many more cells are living and growing down hole in the reservoir bioreactor. The microbe concentration in the bioreactor is at least equal to that of produced microbes.

The presence of a growing microbe colony as proven by this data and analysis indicates Daqing Oilfield chemical and physical reservoir environmental conditions are favorable for these microbes to live and propagate. The ability of these microbes to grow in the reservoir without external nutrients being furnished is the basis of the technology of applying MEOR technology in squeezing and water flooding.

Generation of microbes from oil reservoirs at the rate one thousand times those input provides the scientific foundation for recycled microbial water flooding patented technology.<sup>9</sup>

Laboratory tests were done to measure microbial induced changes in the produced oil after the start of MEOR. Samples from treated wells showed wellhead oil viscosity was reduced by 25% as compared to before MEOR treatment. Well 14-231 and 16-24 show reduced viscosity of 23.2% and 25.4% respectively. Well 14-231 was also tested by comparing chromatography of normal alkane hydrocarbons in the wellhead oil samples before and after the treatment. Figure 2 shows that long-chain alkanes (C36 to C48) were reduced by 49.3%, while short chain alkane (C14 to C24) increased by 21.5%. The microbe bioreactor altered the composition of the crude as it was being produced.

### MEOR Squeeze Treatment Effectiveness

MEOR squeezing treatments were carried out in Production Division 2, 3 and 6, of Daqing Oil Field. Seventy-four MEOR annular-squeeze treatments were performed in 3 batches using 2250 gallons of microbe product. The treatments, which started in September 1997 and concluded in November, were 35 to 40 days-apart (Table 3).

Of the 25 MEOR wells, 17 wells (68%) were effective in improving production performance, increasing fluid production or decreasing water cut so that oil production increased. On other wells, fluid production increased but water cut also increased, so that oil production remained steady or decreased. Table 1 shows MEOR well production well by well.

Individual well response to MEOR treatments is varied. For some wells oil production clearly increased. After the first or second period of microbe injection, produced fluid increased, water cut decreased and oil production increased for these wells: S 3-1-B22, S 3-3-24, S 4-20-424, S 4-D1-118, S 3-1-B20, N 5-8-C62, N 5-9-C63, N 5-9-C65, 14-231, 16-24 and 14-251. Total oil production increased 1796 tons for these eleven wells.

From Table 1 it is apparent that while some wells increased in oil production, others decreased. On many of these wells, factors other than microbes affected production, such as offset water injection changes and oil well production me-

chanical system problems. Any MEOR increase was obscured. Total oil production decreased 1300 tons for the 12 wells. Wells with oil production decreases fall into three categories:

- 1) Changes in offset water injection and mechanical problems.
  - a) S 4-10-423 of Production Division 2 was fractured in April of 1998 and rod-pump parameters were adjusted in June of 1998. The offset injection rate dropped to 15 m<sup>3</sup>/d from 95 m<sup>3</sup>/d. This well had a high production rate before MEOR. After MEOR, the MEOR production increase was obscured by the decreasing trend due to decreased offset water injection. The well decreased 159 tons.
  - b) N 5-10-C64 and well N 4-1-C64 in Production Division 3 decreased 267 tons due to decreases in offset water injection.
  - c) S 3-50-623 in Production Division 2 and 15-232 in Production Division 6 had leaking rod pumps for a time after MEOR treating. They decreased 316 tons of oil.
- 2) High water cut wells. Some of the reservoirs have been under waterflood for a long period, and a great deal of oil has been produced over the past thirty years. The remaining oil saturation on these wells is very low, masking microbes, effectiveness. Also, water velocity in these wells is high, indicating a strong channel from offset injection wells. MEOR squeezing alone could not increase oil production in these wells.
- 3) Low reservoir productivity combined with high water cut, such as in S 3-1-C21, S 3-1-C20, N 5-9-C66.

From the above analysis 938 tons, or most of the 1300 tons of the decreased oil production for 10 wells resulted from reservoir (decreased offset water injection) and mechanical (rod pump) problems.

### Conclusions

Analysis of nearly 2 years of laboratory testing and field MEOR treatments leads to the following conclusions:

1. MEOR has been effective on 17 of 25 oil wells in Daqing Oil Field and over three thousand tons of cumulative incremental oil has been achieved.
2. Living microbe concentrations in the produced water reached approximately the same level as in the microbe products. The concentration is one thousand times that in the diluted microbial products injected. Reservoir environmental conditions in Daqing Oilfield are favorable for growth of these strains of microbes.
3. These strains of microbes have obvious effects on produced oil composition, degrading long-chain normal alkanes and reducing viscosity.
4. Elimination of reservoir and engineering problems is an important guarantee for MEOR pilot test success. Detailed performance analysis of water injection and oil production wells must be emphasized (this job is ongoing).

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## Tables

Table 1 Viscosity Lab Testing and Production Performance Before and After MEOR Treating

Well No.	Visc. Red. in lab %	Before Treatment			After treatment									Cumulative Tons of Oil	Note
		Base			After 1st. Treatment			After 2nd. Treatment			After 3rd. Treatment				
		Fluid t/d	Oil t/d	Water cut %	Fluid t/d	Oil t/d	Water cut %	Fluid t/d	Oil t/d	Water cut %	Fluid t/d	Oil t/d	Water cut %		
S3-1-B22	51.8	5	1	79.2	29	7	77	29	7	77	33	7	79.6	1400	Fluid increased, oil increased by 1998. 9. 7., now increase still 2t/d. Five treatments has been completed.
S3-3-24	61	26	5	76	49	11	77.5	34	9	77.5	41	10	75.5	676	Fluid increased, water cut decreased, oil increased, by 1998. 9. 7., now increase still 2t/d. Five treatments has been completed.
S4-20-424	82.5	31	6	79	32	7	76	23	4	82	23	5	76.5	300	Increased after 3rd treatment. Calculated up till 1997. 12. 3.
S3-50-625	76	8	4	54	7	3	68	10	4	68	12	6	55	144	Fluid increased, water cut increased, 5 treatments done, calculated up till 1998. 9. 7.
S4-10-423	44.9	42	17	59	68	29	62	68	21	62	68	21	62	127	Calculated up till 1997. 12. 31.
S3-2-124	85	38	12	68.6	39	8	78.4	42	15	62	46	12	73.5	111	Calculated up till 1997. 12. 31.
S4-D1-118	80.6	7	4	87	10	5	56	10	6	50	12	5	58.4	64	Fluid increased, water cut decreased.
S3-1-B20	42.0	5	3	31	4	2	77.9	3	2	50	3	2	47	1	The well has very low energy.
S3-1-B21	38.9	4	1	77.9	6	1	89	4	1	78.5	4	1	75.4	0	Fluid increased high water cut well, low energy.
S3-51-622	80.2	17	7	58	23	10	60.1	18	7	67	22	8	64.6	-36	Oil increased, calculated up till 1997. 12. 31.
S4-20-423	36.5	44	6	86	42	8	81	42	8	80	44	7	84.5	-46	Water cut decreased, oil increased.
S3-50-623	83.2	15	6	58	12	6	54	9	3	64	8	3	65	-196	Oil decreased.
S4-21-523	57.4	23	3	87	27	1	97	27	1	97	25	2	90	-196	Water cut increased, oil increased in 3rd. Treatment calculated up till 1997. 12. 31.
S 4-J1-120	•	17	9	16	20	17	13						641	542	Fluid increased, water cut decreased, oil increased.
S 3-2-125	•	37	11	68.8	45	14	69							200	Fluid increased, oil increased.
S 3-J5-319	•	12	7	38	11	7	36							28	
S 3-J3-119	•	25	9	64.2	29	10	65							-12	17 wells (S3-1-B22 to S3-J3-119) are of Division 2.
N5-9-C63	33.6	4	2	50	7	4	42.8	10	6	42	16	11	34		Fluid increased, water cut decreased, calculated up till 1998. 8. 31.
N5-9-C64	38.9	31	3	90.32	21	1	95	25	2	90	33	2	94.3		Fluid decreased, oil increased in 2nd. and 3rd. treatment, calculated up till 1998. 8. 31.
N5-8-C62	31	1	0	100	2	1	50	1	1	30	2	2	24		Fluid increased, water cut decreased, calculated up till 1997. 12. 31.
N5-9-C66	50.5	8	1	87.5	10	1	90	11	1	90	10	1	92.8		Fluid increased• its a well with high water cut.
N5-9-C65	35.3	7	5	28.6	9	7	22	13	8	42	4	3	24		Fluid increased• oil increased
N5-9-C68	31	18	2	88.9	11	1	90	11	1	90	23	2	92.6		Fluid decreased, oil increased in 3rd. treatment, calculated up till 1997. 12. 31.
N5-10-C64	42.3	27	3	88.9	33	3	93.3	26	2	91.6	33	2	92.8		Fluid increased• a well with high water cut, calculated up till 1997. 12. 31.
N4-1-C64	53.1	42	5	88.1	36	4	89	28	3	91	40	4	91		Water increased, fluid decreased, oil increased in 3rd. treatment, a well with high water cut.
N 4-2-C73	21.3	15	3	80.0	10	2	82							0	
La 78	24.5	4	2	41	4	2	38							0	
N 5-9-C67	22.9	11	6	48.0	11	5	50							-111	
N 5-9-C69	21.1	12	4	69.2	11	3	73							-100	12 wells (N5-9-C63 to N5-9-C69) are of Division 3.
14-231	45.7	14	1	89.7	14	4	74.5	12	3	73.4	15	4	75	254	Water cut decreased, calculated up till 1998. 7. 31.
16-24	30.1	34	2	92.7	30	4	85.6	60	6	89.8	40	4	90.7	248	Fluid increased, water cut decreased., a well with high water cut, calculated up till 1998. 7. 31.
14-251	46.5	23	2	90.7	17	2	85.7	19	2	94.4	25	2	92.4	-42	Fluid is increased• its a well with high water cut, calculated up till 1997. 12. 31.
15-232	52.4	23	2	92.8	49	5	89	24	3	88	18	2	91.4	-51	Fluid decreased, oil decreased, a well with high water cut, calculated up till 1998. 7. 31.
Total		539	153		728	195		559	126		600	128		3305	Last 4 wells in this Table are of Division 6.

Table 2

<b>Number of Living Microbes In Produced Water (cfu/ml)</b>				
Colony forming units per milliliter	Daqing Oilfield, Production Division 6			
	Well 14-231	Well 14-251	Well 15-232	Well 16-24
Before MEOR Treating	4.3x10 <sup>3</sup>		1.7x10 <sup>3</sup>	2.7x10 <sup>3</sup>
Days After Well Returned to Production				
After First MEOR Treatment				
1	1.4x10 <sup>4</sup>	6.0x10 <sup>4</sup>	0.7x10 <sup>6</sup>	3.0x10 <sup>4</sup>
2	Shut-in	2.0x10 <sup>5</sup>	1.4x10 <sup>6</sup>	2.0x10 <sup>5</sup>
3	Shut-in	4.9x10 <sup>5</sup>	1.4x10 <sup>6</sup>	4.9x10 <sup>5</sup>
5	Shut-in	Shut-in	1.7x10 <sup>7</sup>	1.1x10 <sup>6</sup>
8	5.0x10 <sup>6</sup>	Shut-in	0.9x10 <sup>7</sup>	1.2x10 <sup>6</sup>
13	1.2x10 <sup>6</sup>	1.7x10 <sup>4</sup>	0.4x10 <sup>5</sup>	1.1x10 <sup>5</sup>
16	1.1x10 <sup>4</sup>		1.7x10 <sup>3</sup>	2.0x10 <sup>3</sup>
20	1.1x10 <sup>3</sup>	1.0x10 <sup>3</sup>	1.7x10 <sup>3</sup>	1.0x10 <sup>3</sup>
23	0.9x10 <sup>3</sup>		1.0x10 <sup>3</sup>	4.9x10 <sup>4</sup>
After Second MEOR Treatment				
1	0.9x10 <sup>3</sup>	1.2x10 <sup>4</sup>	1.1x10 <sup>3</sup>	1.4x10 <sup>3</sup>
2	1.1x10 <sup>5</sup>	1.0x10 <sup>5</sup>	0.8x10 <sup>3</sup>	1.2x10 <sup>4</sup>
3	1.2x10 <sup>6</sup>	4.5x10 <sup>6</sup>	1.7x10 <sup>7</sup>	1.1x10 <sup>5</sup>
5	2.0x10 <sup>5</sup>	Shut-in	1.0x10 <sup>5</sup>	1.2x10 <sup>4</sup>
8		Shut-in		1.2x10 <sup>4</sup>
12	1.0x10 <sup>4</sup>	2.2x10 <sup>5</sup>	0.7x10 <sup>3</sup>	1.1x10 <sup>5</sup>
15	0.8x10 <sup>7</sup>	2.0x10 <sup>7</sup>	1.0x10 <sup>7</sup>	1.0x10 <sup>6</sup>
After Third MEOR Treatment				
1	Flushing		0.2x10 <sup>3</sup>	0.3x10 <sup>3</sup>
2	Flushing		0.3x10 <sup>3</sup>	0.4x10 <sup>3</sup>
3	0.3x10 <sup>6</sup>		0.4x10 <sup>3</sup>	0.3x10 <sup>3</sup>
7	1.1x10 <sup>6</sup>		3.5x10 <sup>3</sup>	1.6x10 <sup>6</sup>
10	2.0x10 <sup>5</sup>		1.1x10 <sup>4</sup>	1.3x10 <sup>6</sup>
14	0.7x10 <sup>5</sup>		3.1x10 <sup>5</sup>	1.5x10 <sup>6</sup>
16	4.3x10 <sup>3</sup>		2.5x10 <sup>4</sup>	Shut-in

**Table 3 Treatment Size**

Well no.	1st Treatment			2nd Treatment			3rd Treatment		
	Treatment Size m <sup>3</sup>	Mi- crobe Product gals.	Date	Treatment Size m <sup>3</sup>	Mi- crobe Product gals.	Date	Treatment Size m <sup>3</sup>	Mi- crobe Product gals.	Date
S4-21-523	24	40	9.13	12	20	10.17	15	30	11.28
S4-20-423	24	40	10.17	24	40	10.17	15	26	11.28
S3-51-622	24	40	9.12	8	20	10.16	10	26	11.28
S4-10-423	24	40	9.12	12	20	10.17	15	32	11.28
S3-50-625	24	40	9.13	6	19	10.17	9	28	11.28
S3-50-623	24	40	9.13	10	20	10.16	12	30	11.28
S3-3-24	24	40	9.12	12	20	10.16	15	30	11.28
S3-2-124	36	60	9.13	14	28	10.16	18	34	11.28
S3-1-B21	24	40	9.12	8	20	10.16	10	25	11.28
S3-1-B22	24	40	9.13	6	20	10.16	9	28	11.28
S4-D1-118	24	40	9.12	8	20	10.17	12	29	11.28
S4-20-424	24	40	9.13	10	20	10.16	15	32	11.28
S3-1-B20	24	40	9.13	6	20	10.16	9	31	11.28
<b>Total of Div. 2</b>	<b>324</b>	<b>540</b>		<b>136</b>	<b>287</b>		<b>164</b>	<b>381</b>	
N4-1-C64	36	60	9.18	12	30		15	40	11.28
N5-8-C62	24	40	9.19	6	20	10.16	9	27	11.28
N5-9-C63	24	40	9.19	6	19	10.16	9	26	11.28
N5-9-C64	24	40	9.18	12	20	10.16	15	25	11.28
N5-9-C65	24	40	9.19	6	19	10.16	9	27	11.28
N5-9-C66	24	40	9.18	12	20	10.16	15	27	11.28
N5-9-C68	24	40	9.18	12	20	10.16	15	30	11.28
N5-10-C64	24	40	9.19	12	20	10.16	15	29	11.28
<b>Total of Div.3</b>	<b>204</b>	<b>340</b>		<b>78</b>	<b>168</b>		<b>102</b>	<b>231</b>	
14-231	24	40	9.18	12	20	10.17	12	30	11.29
15-232	24	40	9.18	12	20	10.17	12	31	11.29
14-251	24	40	9.19	12	20	10.17	12	30	11.29
16-24	24	40	9.18	12	20	10.17	12	29	11.29
<b>Total of Div.6</b>	<b>96</b>	<b>160</b>		<b>48</b>	<b>80</b>		<b>48</b>	<b>120</b>	
<b>Total of 3 Divs.</b>	<b>624</b>	<b>1040</b>		<b>262</b>	<b>535</b>		<b>314</b>	<b>732</b>	

Figures

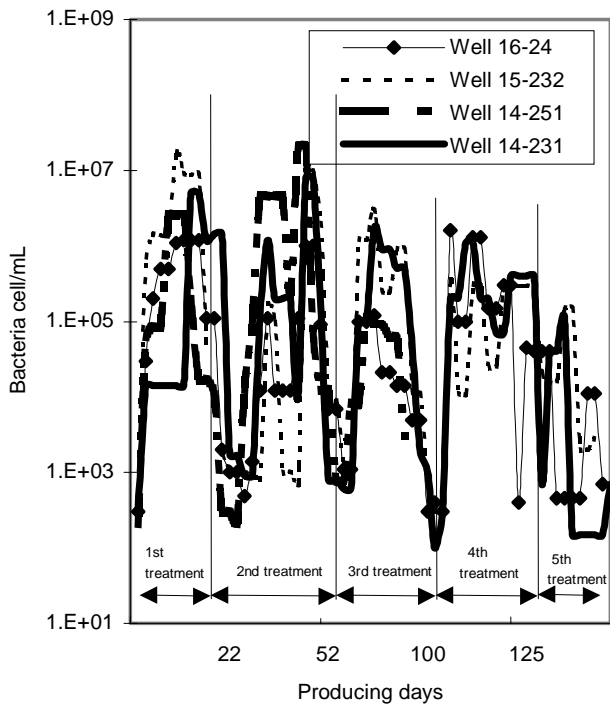


Fig. 1 Bacterial Concentration of Produced Water of MEOR Test Well

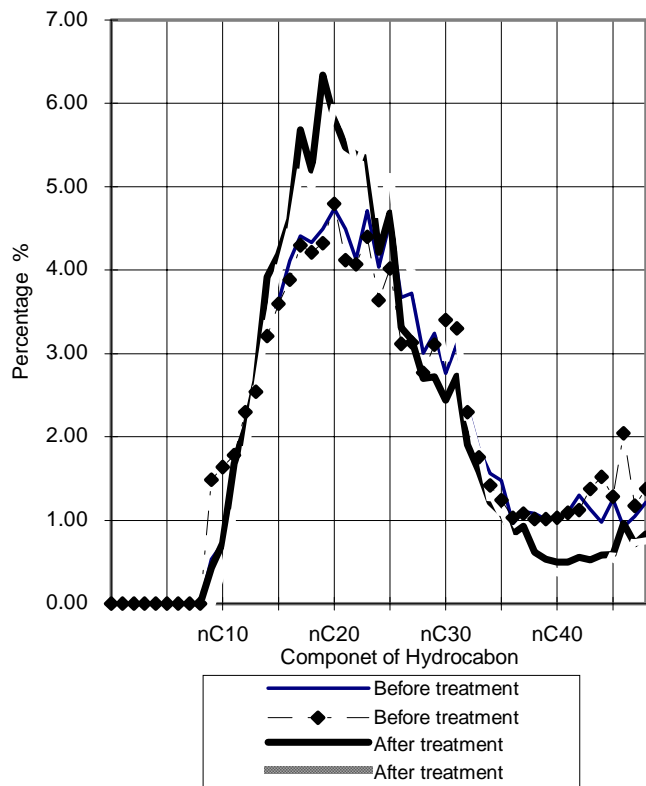


Fig. 2 Chromatogram of Saturated Hydrocarbon of Well 14-231