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Using Flue Gas Huff 'n Puff Technology and Surfactants to Increase Oil  
Production from the Antelope Shale Formation of the Railroad Gap Oil  
Field

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December 2001

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## **ABSTRACT:**

The Antelope Shale formation at Railroad Gap field in Kern County California is a high-porosity, low-permeability reservoir. Despite the large amount of oil originally in place, recovery to date has been low, with only about 10% of the original oil produced. This project was designed to test cyclic injection of exhaust flue gas from compressors located in the field to stimulate production from Antelope Shale zone producers. Approximately 17,000 m<sup>3</sup> (±600 MCF) of flue gas was to be injected into each of three wells over a three-week period, followed by close monitoring of production for response. Flue gas injection on one of the wells would be supplemented with a surfactant.

Further design of equipment needed to cool and compress the flue gas revealed rental costs were high than anticipated, but could be tolerated. Refusal of the San Joaquin Valley Unified Air Pollution Control District to issue a research variance for equipment needed for the project imposed additional costs and timing burdens that ultimately prevented execution of the project at the field level.



## INTRODUCTION

The Railroad Gap oil field is located on the west side of the San Joaquin Valley in California (see Figure 1-1). It is about sixty kilometers (thirty-seven miles) west of Bakersfield and two and one-half kilometers (one and one-half mile) northeast of the town of McKittrick, in Kern County. The Antelope Shale formation contains large volume of light (32° API) oil. The primary production processes, solution gas drive and natural water drive, have not been efficient in recovering the oil. Recovery is 10% or less, leaving approximately 90% of the original oil still in place. Finding effective solutions to increase production and recovery in the Antelope Shale formation has been a challenge to both major and independent oil producers operating the area.

Signal Oil Company completed the first commercial well in the Railroad Gap oil field during 1948<sup>1</sup>. Standard Oil Company of California started significant development of the Antelope Shale in 1964. Standard ultimately drilled or produced 26 wells as Antelope Shale zone producers in the main area of the field.

The structure of the Railroad Gap field is a doubly-plunging, slightly asymmetric anticline, trending northwest-southeast. The structure is shown by the contour map in Figure 1-2, in Appendix 1. There are eight productive zones in the Railroad Gap oil field. Figures 1-3 and 1-4 in Appendix 1 are cross-sections showing the Antelope Shale and several other productive intervals.

The Antelope Shale zone is found in the top 305 to 366 meters (1000 to 1200 feet) of the Antelope formation, at an average depth of 1450 meters (4,750 feet). The Antelope Shale is a siliceous Monterey reservoir, composed largely of the accumulated skeletal remains of diatoms. It is characterized by high porosity and very low matrix permeability. Natural fractures and thin sand layers contribute permeability to the zone.

Productive limits in the Antelope Shale are controlled by an oil-water contact at  $\pm$  -1657 meters ( $\pm$  -5050 feet) sub-sea, and by permeability variations. Current understanding of fracture patterns and oil saturation distributions is incomplete, and the true potential of the Antelope Shale is difficult to assess. The Antelope Shale reservoir is still producing under primary recovery, with only five producers remaining active in late 1998. Cumulative production through December 1998 is over 318,000 m<sup>3</sup> (2 million barrels) of oil and 251,000 m<sup>3</sup> (9.7 MMSCF) of gas, with oil recovery estimated at  $\pm$ 10% of oil originally in place.

The objective of this project was to test the use of flue gas injection as an economic method of improving recovery from the Antelope Shale. Flue gas is a waste product of internal combustion engines that power natural gas compressors in the field. The compressors are used to increase the pressure of

produced natural gas to allow sale to a pipeline. The compressors generated about 280 – 560 m<sup>3</sup> (1 – 2 MMCF) of flue gas exhaust per day during late 1998. Flue gas is composed mainly of nitrogen and carbon dioxide, with a small amount of oxygen and trace amounts of light hydrocarbons.

The concept of this project is that recovery and production rates will be improved because of viscosity reduction and 'swelling' of the produced oil, caused by absorption of the carbon dioxide into the oil. Inert gasses in the flue gas would also improve production by filling reservoir porosity and increasing near-wellbore pressure.

The project design included injecting flue gas into three idle wells located on the flank of the structure. Flue gas would be injected at rates of ±860 m<sup>3</sup> (±30 MCF) per day per well for approximately three weeks, for total volumes of 17,000 m<sup>3</sup> (±600 MCF) per well. Injection pressure would be limited to the 13,800 Kpa (2000 psi) working pressure of the wellhead equipment. After injection, the wells would be shut in for a one-week 'soak' period, then returned to production. Routine well testing would monitor production rates from the wells, and deviations from projected rates would be analyzed, and if appropriate, attributed to injection response.

A secondary objective was to test a surfactant additive to flue gas to determine its effect on recovery. One of the wells would be treated with surfactant before flue gas was injected, and monitored for production improvement. The surfactant was expected to increase production by reducing interfacial tension between the oil and the reservoir rock. The test wells are shown in Figure 1-5. Wellbore diagrams for the wells are shown in Figures 3-1 through 3-3, and production curves for the wells are shown in Figures 4-2 through 4-4.

## EXECUTIVE SUMMARY

The Railroad Gap oil field is located on the west side of the San Joaquin Valley in California (see Figure 1-1). It is about sixty kilometers (thirty-seven miles) west of Bakersfield and two and one-half kilometers (one and one-half mile) northeast of the town of McKittrick, in Kern County. The Antelope Shale formation at Railroad Gap field is thick, has high porosity, and has a large volume of oil in place. However, permeability is extremely low, and the primary production processes have been inefficient in recovering the oil. Recovery is estimated at 10% or less of the original oil still in place. Finding effective solutions to increase production and recovery in the Antelope Shale formation has been a challenge to both major and independent oil producers operating the area.

This project was designed to test the response of Antelope Shale zone producers to cyclic flue gas injection. It was believed that the carbon dioxide in the flue gas would reduce the viscosity of the oil. It would also increase the volume of the oil after the gas was absorbed, in effect causing the oil to 'swell'. Finally, the remaining components in the flue gas would increase local reservoir pressure, which would result in increased production. Approximately 17,000 m<sup>3</sup> ( $\pm$ 600 MCF) of flue gas would be injected into each of three wells over a three-week injection period, followed by a one-week shut-in period. After return to production, the wells would be closely monitored by well testing. Deviations from expected rates would be evaluated to determine if they were caused by the treatments. One of the test wells would be treated with a surfactant before injection to test its effect on production response.

A more detailed analysis of the facilities required to handle the flue gas, specifically cooling and compression, revealed that capital costs were going to be greater than expected in the original proposal. The project was terminated when the local air pollution control regulatory agency refused to grant a research exemption for one of the critical components needed for gas compression. Additional financial and timing costs needed to obtain the required permits were judged to be excessive, and the project to be terminated before any significant field work was conducted.



## **EXPERIMENTAL**

Injection was never initiated because of several reasons, discussed under Results and Discussion. Therefore, only very limited experimental results were obtained. The results are restricted to analysis of the flue gas, and are shown in Appendix 2.

Analyses are included for flue gas from each of the two compressors in Railroad Gap field. There are two analyses for one compressor, designated UC15Z, and one analysis for a second compressor designated RC15Z. The composition of each sample was 84.5 to 85.6 mole percent nitrogen, 4.1 to 4.2 mole percent oxygen, and 10.3 to 10.7 mole percent carbon dioxide. Residual, unburned light hydrocarbons were 0.12 mole percent or less.



## RESULTS AND DISCUSSION

Injection of flue gas was never initiated because of two reasons. First, further design of equipment for the project resulted in equipment costs that exceeded the original estimates. Handling of the flue gas before it could be injected proved to be a complicated, expensive process. Second, regulatory requirements for necessary equipment were such that it was impossible to obtain operating permits in a timely, cost-effective manner.

Flue gas was available at its source as hot, low-pressure exhaust. The exhaust temperature and pressure is  $\pm 480^{\circ}\text{C}$  ( $900^{\circ}\text{F}$ ), and  $\pm 97$  kPa ( $\pm 14$  PSIA), respectively. In order to be injected, it had to be cooled significantly, then compressed to 6,900 – 13,800 kPa (1000-2000 PSI). This required considerable process equipment not available at the location. Estimates of costs to purchase the equipment to handle the cooling and compression ranged to over \$500,000. Purchasing the equipment for the test was clearly too expensive for the short-term testing included in this program. The project proposal therefore included funds to rent the necessary equipment. Rental costs for adequate compression was ~\$9,700 per month, compared to \$3,000 per month included in the project proposal. Equipment to cool the gas before compression, and to remove corrosive components, was still required. Although extremely expensive, it was still feasible to conduct the project with these costs.

Because of the remote location of the field adequate electric service was unavailable and prohibitively expensive to install to allow using electric prime movers for the compressors. Based on the availability of natural gas for fuel, Naftex determined to rent a compressor with a gas-fired internal combustion prime mover. The San Joaquin Valley Air Pollution Control District (APCD) is the local regulatory agency responsible for maintaining air quality in this region of California. The APCD required an operating permit for the additional internal combustion engine, but rejected an application for a research exemption. In order to proceed with the project, Naftex Operating Company would be required to undergo a lengthy and expensive process to obtain the necessary permit. Correspondence between Naftex and the APCD is included as Appendix 5. The expense associated with obtaining Air District permits was excessive for the short duration of the test. When this was combined with the high costs of gas-handling equipment, the project was no longer feasible and was terminated at this point.



## **CONCLUSION**

Expenses for equipment and strict permitting requirements proved excessive when weighed against the uncertainty of the project and the short time frame involved. As a result, the project was terminated before significant work was performed in the field.

The potential of this technique in the Antelope Shale still has not adequately been tested. Small, short-term projects of this type are extremely difficult to conduct because of the capital requirements for gas handling, and because of permitting requirements for the equipment. However, relatively small improvements in recovery in the Antelope Shale result in significant production increases. This suggests that further investigation is warranted. Any future projects of this nature should anticipate stringent environmental permitting obstacles. With adequate lead-time, it may be possible to negotiate a more flexible permitting arrangement with regulatory agencies.



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## **LIST OF ACRONYMS AND ABBREVIATIONS**

APCD – San Joaquin Valley Unified Air Pollution Control District

ATC – Authority to Construct

CO<sub>2</sub> – Carbon dioxide

DOE – Department of Energy

EOR – Enhanced Oil Recovery

Kpa - kilopascals

m<sup>3</sup> – cubic meters

MCF – thousand cubic feet

MMSCF – million cubic feet

NO<sub>x</sub> – Oxides of nitrogen

NOV – Notice of Violation

NTC – Notice to Comply

psi – pounds per square inch

PTO – Permit to Operate



## **APPENDIX 1 – Maps and Cross-Sections**



Figure 1-1 - California locator map (after California Oil & Gas Fields)

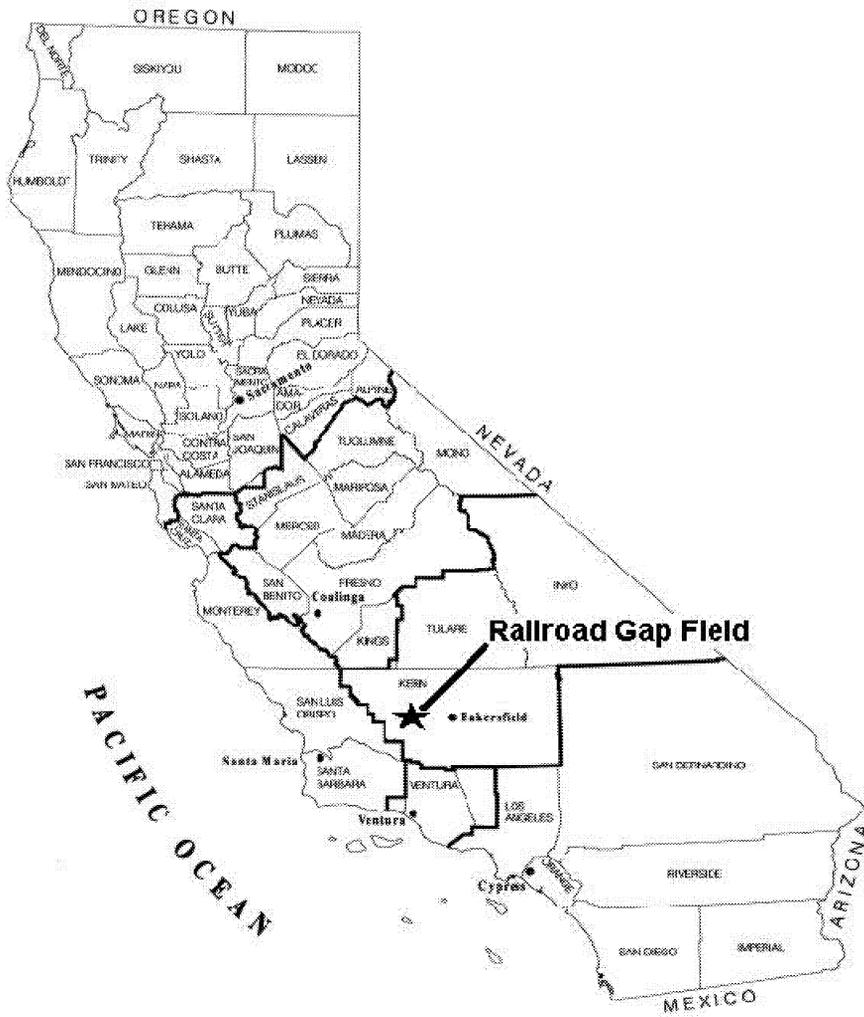






Figure 1-4 - Cross-Section C-D through Railroad Gap Field

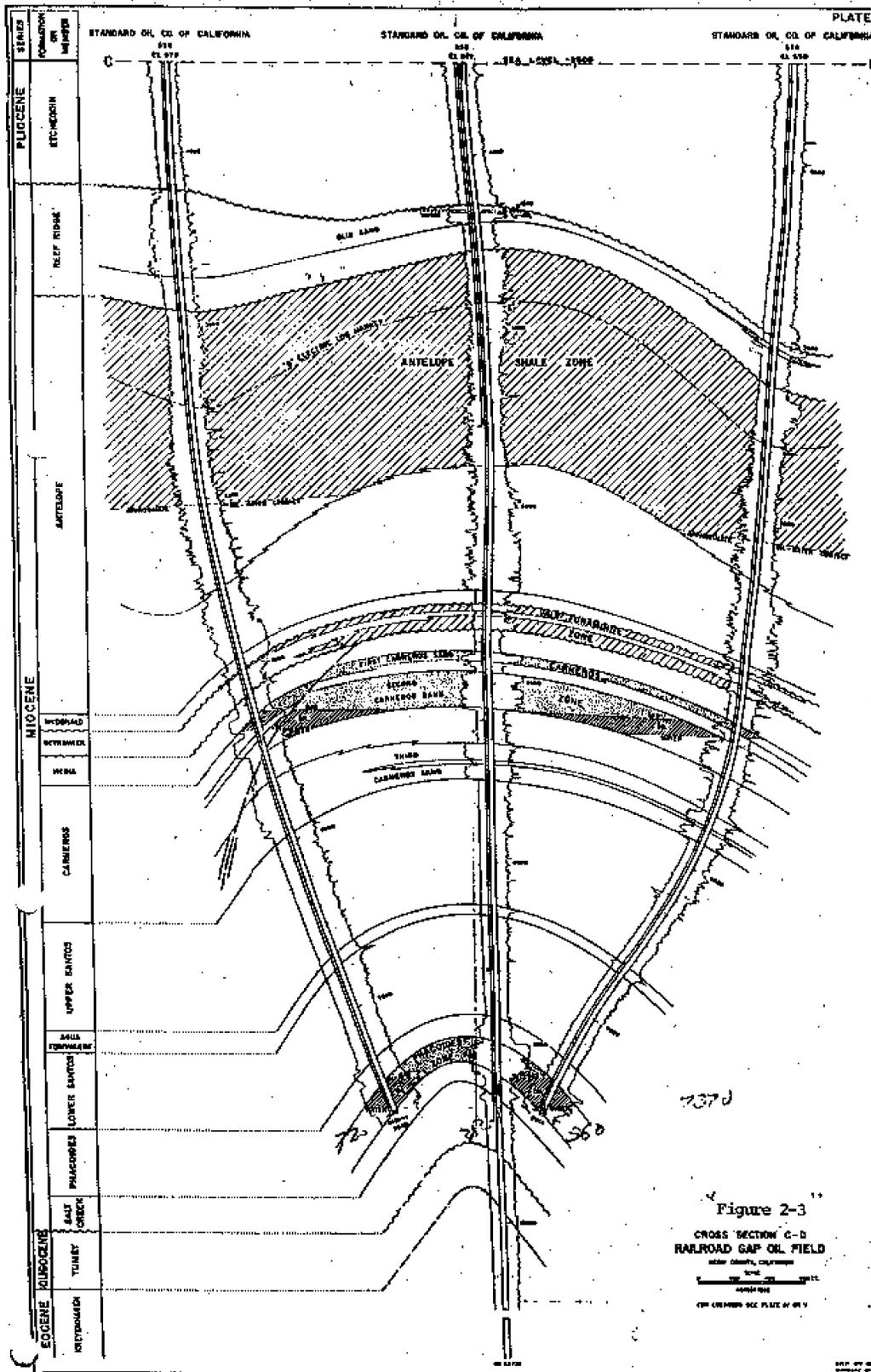


Figure 2-3  
 CROSS SECTION C-D  
 RAILROAD GAP OIL FIELD  
 1937





## **APPENDIX 2 – Test Results**





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(661) 385-0539  
FAX (661) 395-3069

NAFTEX Holdings, LTD.  
1801 Avenue of the Stars, Ste. 301  
Los Angeles CA 90067

Laboratory No: 9910248-1  
Date Received: 10/19/99  
Date Analyzed: 10/20/99  
Purchase Order:

Attention: Max Juprasert  
CC:

Date Reprinted: 10/20/99  
Test Code: 1610-1645

Sample Description: RC152 Internal Combustion Engine Exhaust  
Sampled 10/19/99 by Chris Addis, Genesis. Combined GC-TCD and FID Test Results.

CHNS Chromatographic Analysis, ASTM D-1945-81, ASTM D-3588-89, GPA 2145-94

Constituent	Norm Mol%	Norm Wt%	GPM
Oxygen	4.15451	4.45988	
Nitrogen	84.58161	79.48974	
Carbon Dioxide	10.27253	15.16694	
Carbon Monoxide	0.85850	0.80672	
Methane	0.12237	0.06586	
Ethane	0.00988	0.00997	
Propane	0.00060	0.00089	0.00017
IsoButane	0.00000	0.00000	0.00000
n-Butane	0.00000	0.00000	0.00000
IsoPentane	0.00000	0.00000	0.00000
n-Pentane	0.00000	0.00000	0.00000
Hexanes +	0.00000	0.00000	0.00000
Heptanes	0.00000	0.00000	0.00000
Octanes	0.00000	0.00000	0.00000
Nonanes	0.00000	0.00000	0.00000
Decanes+	0.00000	0.00000	0.00000
Totals:	100.00000	100.00000	0.00017
Gas Properties calculated at STP:	degrees F.	60.000	
Measurement Base Pressure at STP:	psia	14.696	
Gross Btu/Cu.Ft., Dry Gas	4.2	Relative Gas Density, {Ideal}	1.02919
Ideal Gross Btu/lb., Dry Gas	53.2	Specific Gravity, [Air=1]	1.02915
Net Btu/Cu.Ft., Dry Gas	4.0	Real Gas Density, lb./Cu.Ft.	0.07859
Ideal Net Btu/lb., Dry Gas	51.4	Specific Volume, Cu.Ft./lb.	12.72401
Gross Btu/Cu.Ft., water saturated	4.1	Compressibility, %	0.99945

Jim Edlerion  
Laboratory Operations Manager

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1801 Avenue of the Stars, Ste. 301  
Los Angeles CA 90067

Laboratory No: 9910229-1rep  
Date Received: 10/18/99  
Date Analyzed: 10/19/99  
Purchase Order:

Attention: Max Juprasert  
CC:

Date Reprinted: 10/20/99  
Test Code: 1610+1645

Sample Description:  
UC15Z Internal Combustion Engine Exhaust (Resample of Lab. No. 9910120). Bag 2.  
Sampled 10/18/99 by Max Juprasert. Combined GC-TCD and FID Test Results.

CHNS Chromatographic Analysis, ASTM D-1945-81, ASTM D-3588-89, GPA 2145-94

Constituent:	Norm Mol%	Norm Wt%	GPM
Oxygen	4.21851	4.51788	
Nitrogen	85.03707	79.72896	
Carbon Dioxide	10.66283	15.70601	
Carbon Monoxide	0.00000	0.00000	
Methane	0.07473	0.04012	
Ethane	0.00660	0.00664	
Propane	0.00026	0.00038	0.00007
IsoButane	0.00000	0.00000	0.00000
n-Butane	0.00000	0.00000	0.00000
IsoPentane	0.00000	0.00000	0.00000
n-Pentane	0.00000	0.00000	0.00000
Hexanes +	0.00000	0.00000	0.00000
Heptanes	0.00000	0.00000	0.00000
Octanes	0.00000	0.00000	0.00000
Nonanes	0.00000	0.00000	0.00000
Decanes+	0.00000	0.00000	0.00000
Totals:	100.00000	100.00000	0.00007
Gas Properties calculated at STP: degrees F.		60.000	
Measurement Base Pressure at STP: psia		14.696	
Gross Btu/Cu.Ft., Dry Gas	0.9	Relative Gas Density, {Ideal}	1.03163
Ideal Gross Btu/lb., Dry Gas	11.2	Specific Gravity, [Air=1]	1.03160
Net Btu/Cu.Ft., Dry Gas	0.8	Real Gas Density, lb./Cu.Ft.	0.07878
Ideal Net Btu/lb., Dry Gas	10.1	Specific Volume, Cu.Ft./lb.	12.69383
Gross Btu/Cu.Ft., water saturated	0.9	Compressibility, 'z'	0.99944

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Laboratory No: 9910229-1  
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Date Analyzed: 10/19/99  
Purchase Order:

Attention: Max Juprasert  
CC:

Date Reprinted: 10/19/99  
Test Code: 1610+1645

Sample Description:  
UC15Z Internal Combustion Engine Exhaust (Resample of Lab. No. 9910120).  
Sampled 10/18/99 by Max Juprasert. Combined GC-TCD and FID Test Results.

CHN5 Chromatographic Analysis, ASTM D-1945-81, ASTM D-3588-89, GPA 2145-94

Constituent:	Norm Mol%	Norm Wt%	GPM
Oxygen	4.44397	4.76255	
Nitrogen	84.82333	79.58208	
Carbon Dioxide	10.51884	15.50434	
Carbon Monoxide	0.00000	0.00000	
Methane	0.13748	0.07387	
Ethane	0.07585	0.07639	
Propane	0.00053	0.00078	0.00015
IsoButane	0.00000	0.00000	0.00000
n-Butane	0.00000	0.00000	0.00000
IsoPentane	0.00000	0.00000	0.00000
n-Pentane	0.00000	0.00000	0.00000
Hexanes +	0.00000	0.00000	0.00000
Heptanes	0.00000	0.00000	0.00000
Octanes	0.00000	0.00000	0.00000
Nonanes	0.00000	0.00000	0.00000
Decanes+	0.00000	0.00000	0.00000
Totals:	100.00000	100.00000	0.00015
Gas Properties calculated at STP: degrees F.		60.000	
Measurement Base Pressure at STP: psia		14.696	
Gross Btu/Cu.Ft., Dry Gas	2.7	Relative Gas Density, {Ideal}	1.03093
Ideal Gross Btu/lb., Dry Gas	34.9	Specific Gravity, [Air=1]	1.03091
Net Btu/Cu.Ft., Dry Gas	2.5	Real Gas Density, lb./Cu.Ft.	0.07873
Ideal Net Btu/lb., Dry Gas	31.7	Specific Volume, Cu.Ft./lb.	12.70237
Gross Btu/Cu.Ft., water saturated	2.7	Compressibility, 'z'	0.99944

Jim Eberton  
Laboratory Operations Manager

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Lab No: 9910229\_001  
Received: 10/18/99  
Analyzed: 10/19/99  
Reported: 10/19/99

Attn: Max Juprasert

Description: UX15Z I.C. Engine  
Sampled: 10/18/99 By Client

Chromatographic Analysis (Z-1645)

Component	TOG ppmv
Methane	1374.812
Ethane	75.848
Propane	5.285
Totals	1455.945
Reactive Organic Compounds (less C1)	81.133
Reactive Organic Compounds (less C1+C2)	5.285

References: ASTM E-260-73, ASTM D-3538-89, ASTM D-1945-81

TOG: Total Organic Gas ( Hydrogen/Carbon Compounds)  
ROC: Reactive Organic Compounds ( TOG - Exempt Compounds)

CCS  
Analyst

  
Jim Etherton  
Laboratory Director

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## **APPENDIX 3 – Wellbore Diagrams**



Figure 3-1 345-15Z Wellbore Diagram

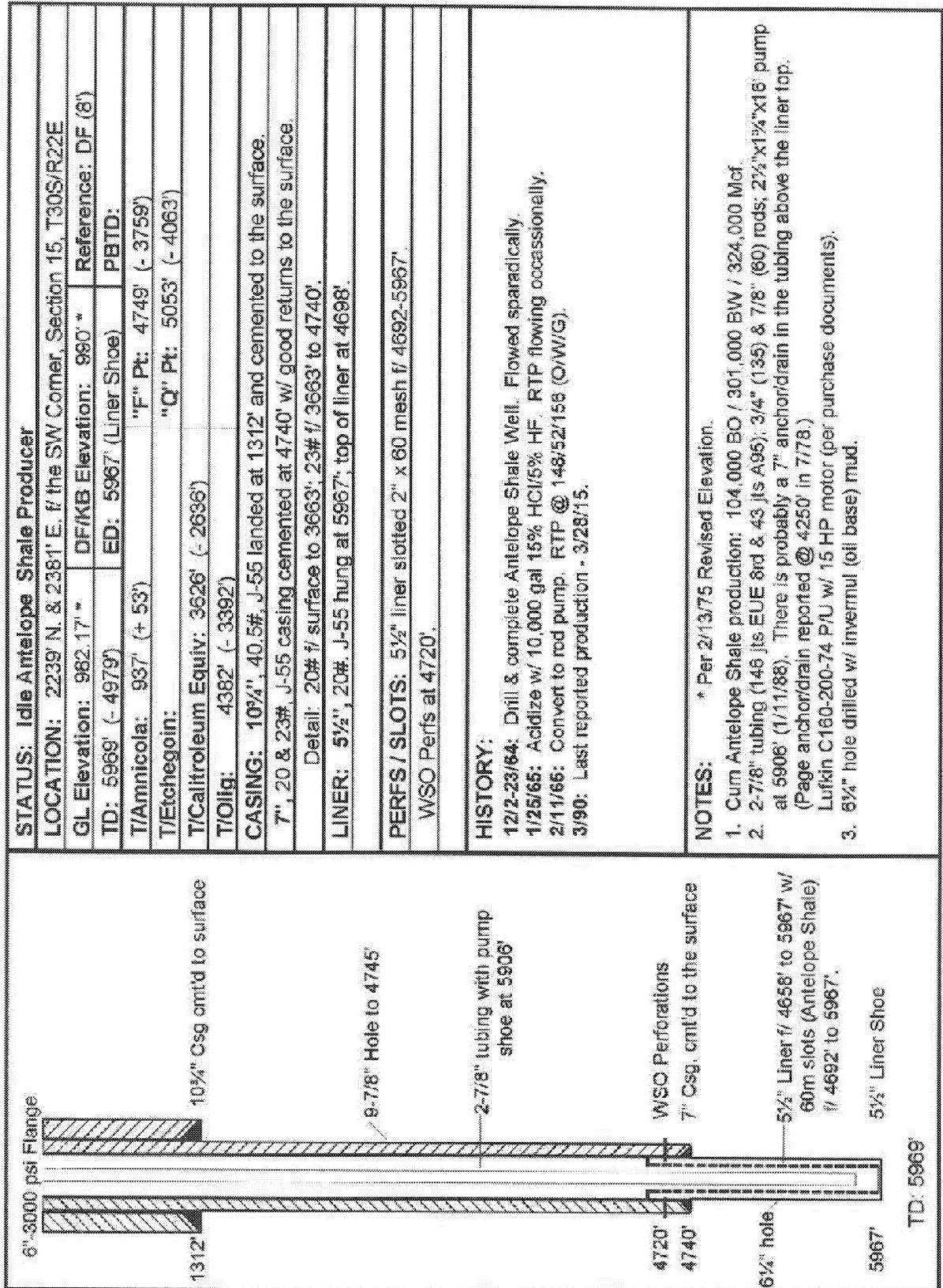
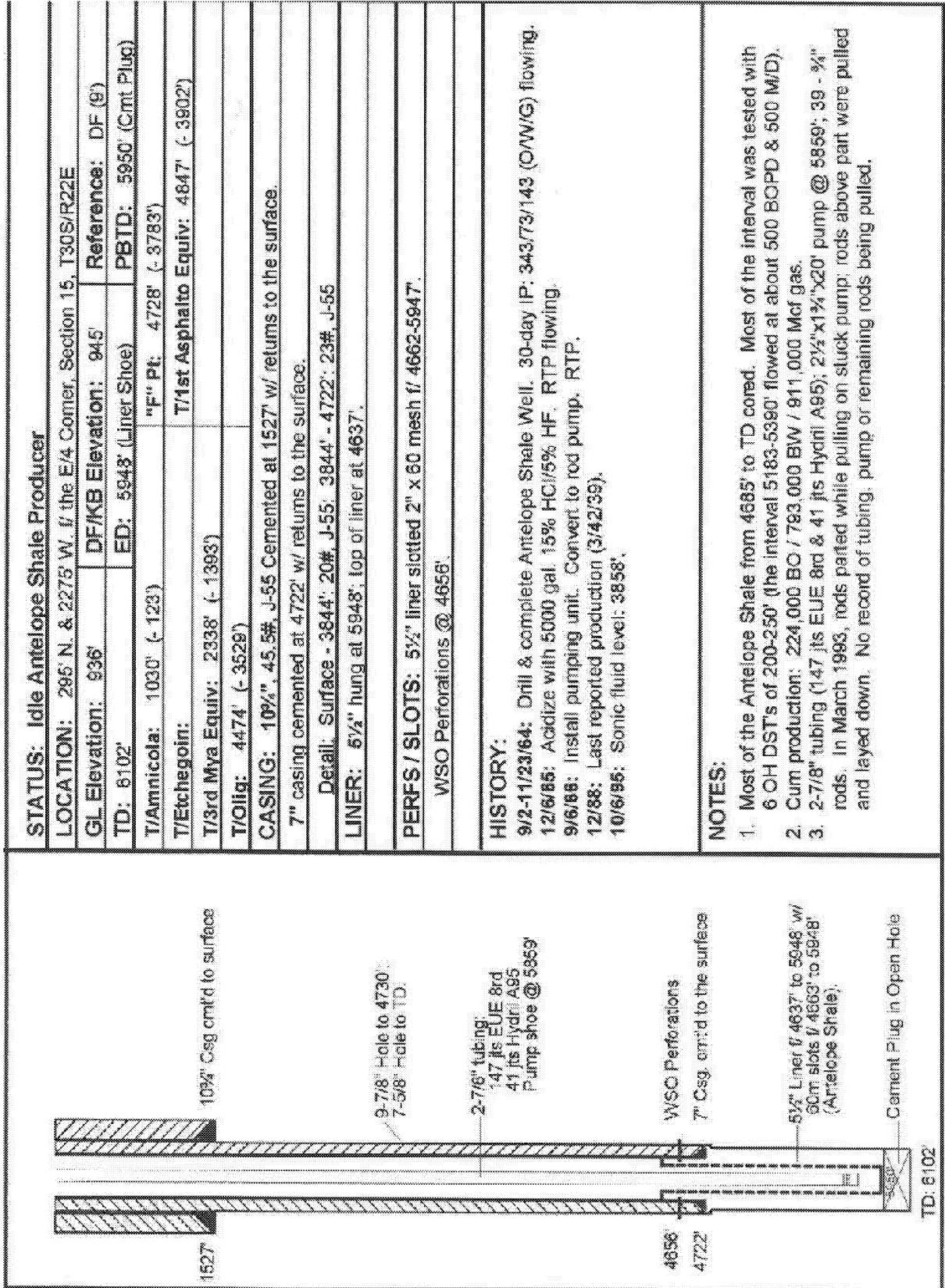
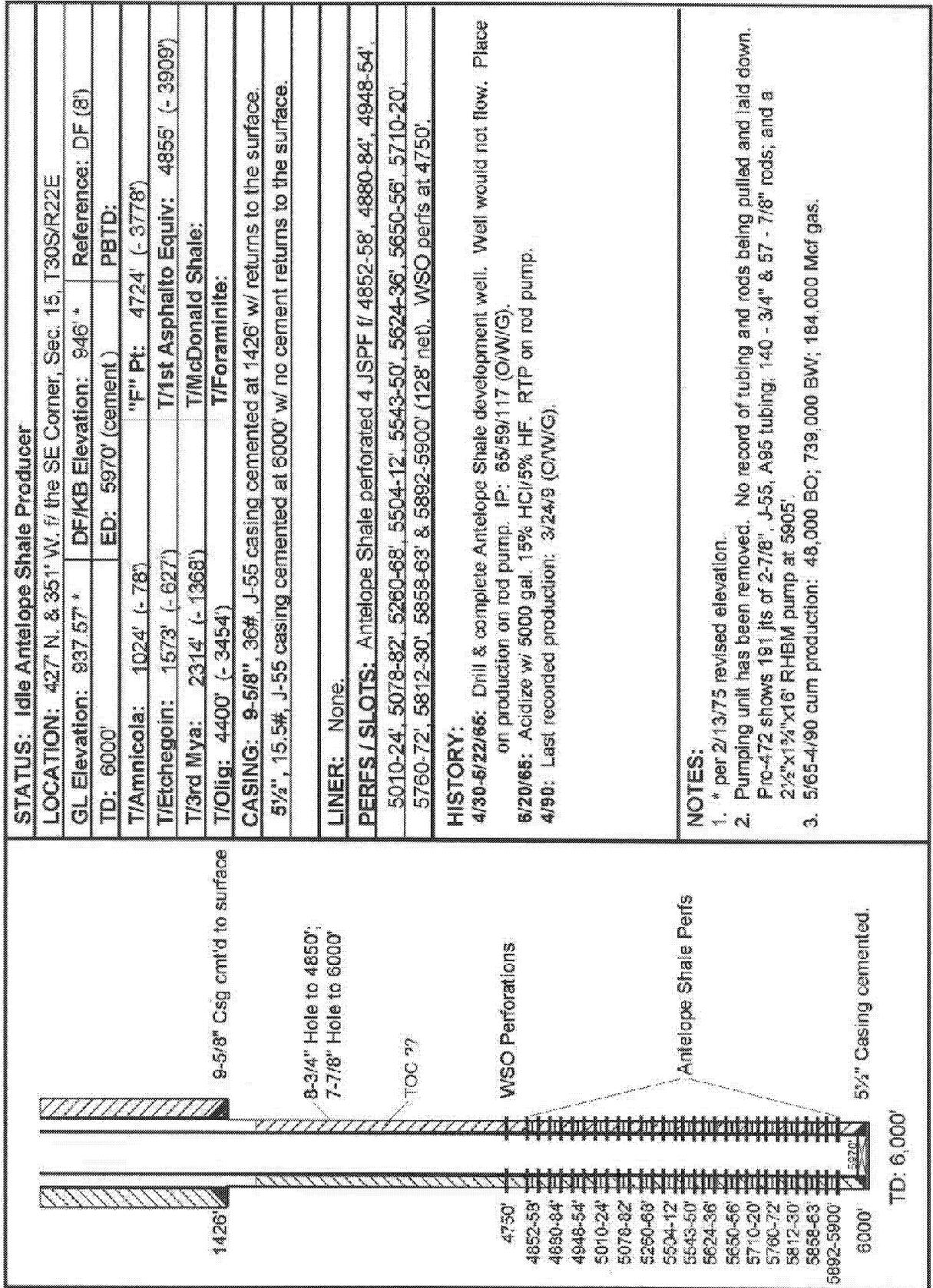


Figure 3-2 354-15Z Wellbore Diagram



<b>STATUS:</b> Idle Antelope Shale Producer	
<b>LOCATION:</b> 296' N. & 2275' W. of the E/4 Corner, Section 15, T30S/R22E	
<b>GL Elevation:</b> 936'	<b>DF/KB Elevation:</b> 945'
<b>Reference:</b> DF (g)	<b>PBTD:</b> 5950' (Cmt Plug)
<b>TD:</b> 6102'	<b>ED:</b> 5948' (Liner Shoe)
<b>T/Amnicola:</b> 1030' (-123')	<b>"F" Pt:</b> 4728' (-3783')
<b>T/Etchegoin:</b>	<b>T/1st Asphalt Equiv:</b> 4847' (-3902')
<b>T/3rd Mya Equiv:</b> 2338' (-1393')	
<b>T/Olig:</b> 4474' (-3529')	
<b>CASING:</b> 10 3/4" 45.5# J-55 Cemented at 1527' w/ returns to the surface.	
7" casing cemented at 4722' w/ returns to the surface.	
<b>Detail:</b> Surface - 3844'; 20# J-55; 3844' - 4722'; 23# J-55	
<b>LINER:</b> 5 1/2" hung at 5948'; top of liner at 4637'.	
<b>PERFS / SLOTS:</b> 5 1/2" liner slotted 2" x 60 mesh ft 4662-5947'.	
WSO Perforations @ 4656'	
<b>HISTORY:</b>	
9/2-11/23/64: Drill & complete Antelope Shale Well. 30-day IP: 343/73/143 (O/W/G) flowing.	
12/6/68: Acidize with 5000 gal. 15% HCl/5% HF. RTP flowing.	
9/6/68: Install pumping unit. Convert to rod pump. RTP.	
12/68: Last reported production (3/42/39).	
10/6/95: Sonic fluid level: 3858'.	
<b>NOTES:</b>	
1. Most of the Antelope Shale from 4685' to TD cored. Most of the interval was tested with 6 OH DST's of 200-250' (the interval 5183-5390' flowed at about 500 BOPD & 500 M/D).	
2. Cum production: 224,000 BO / 783,000 BW / 911,000 Mcf gas.	
3. 2-7/8" tubing (147 lbs EUE 8rd & 41 lbs Hydril A95); 2 1/2" x 1 1/2" x 20' pump @ 5859'; 39 - 3/4" rods. In March 1993, rods parted while pulling on stuck pump; rods above part were pulled and layed down. No record of tubing; pump or remaining rods being pulled.	

Figure 3-3 388-15Z Wellbore Diagram





## **APPENDIX 4 – Production Curves**



Figure 4-1

### Railroad Gap Field Total Antelope Shale Zone Production

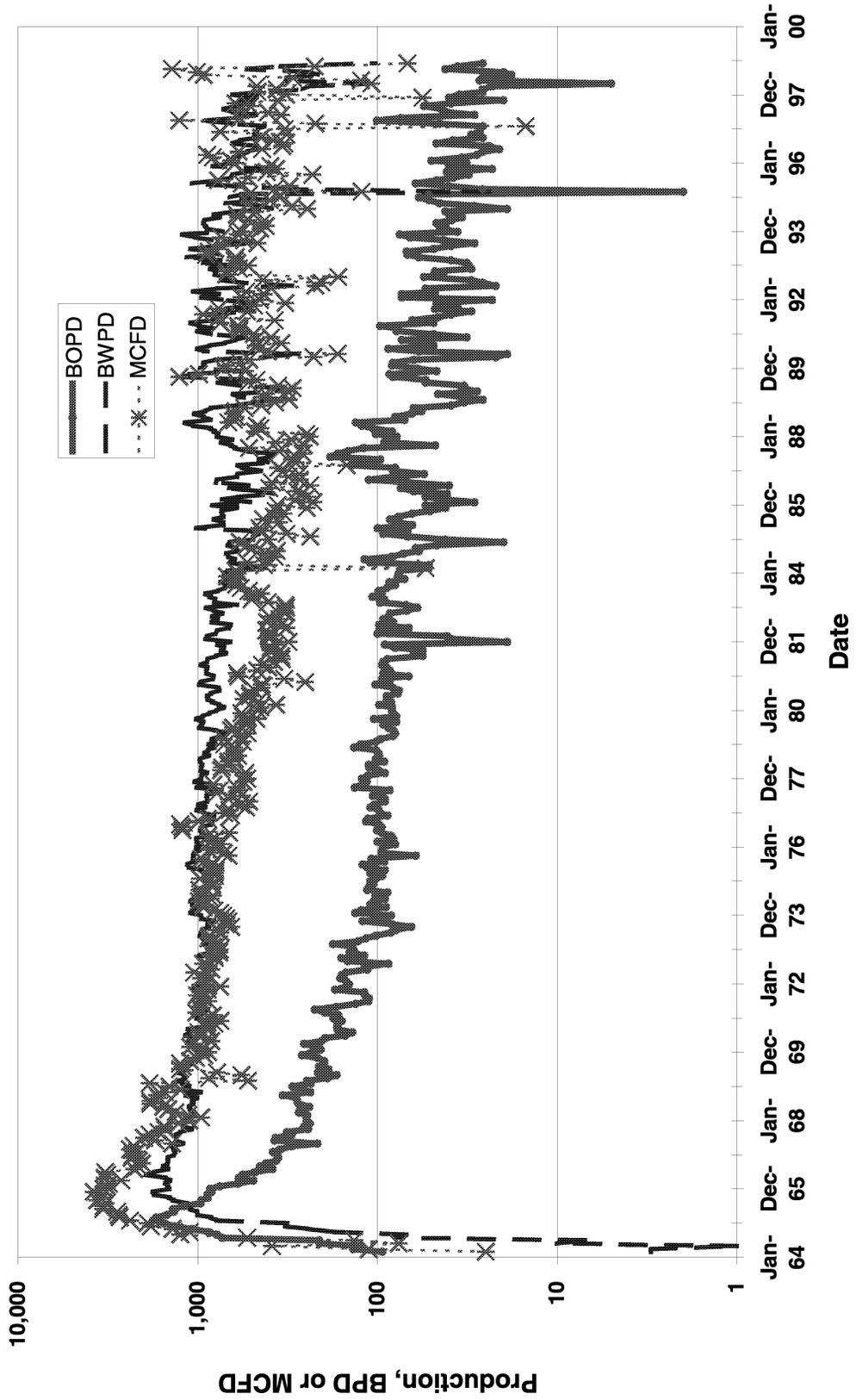


Figure 4-2

**Railroad Gap Field  
Antelope Shale Zone Well 345-15Z**

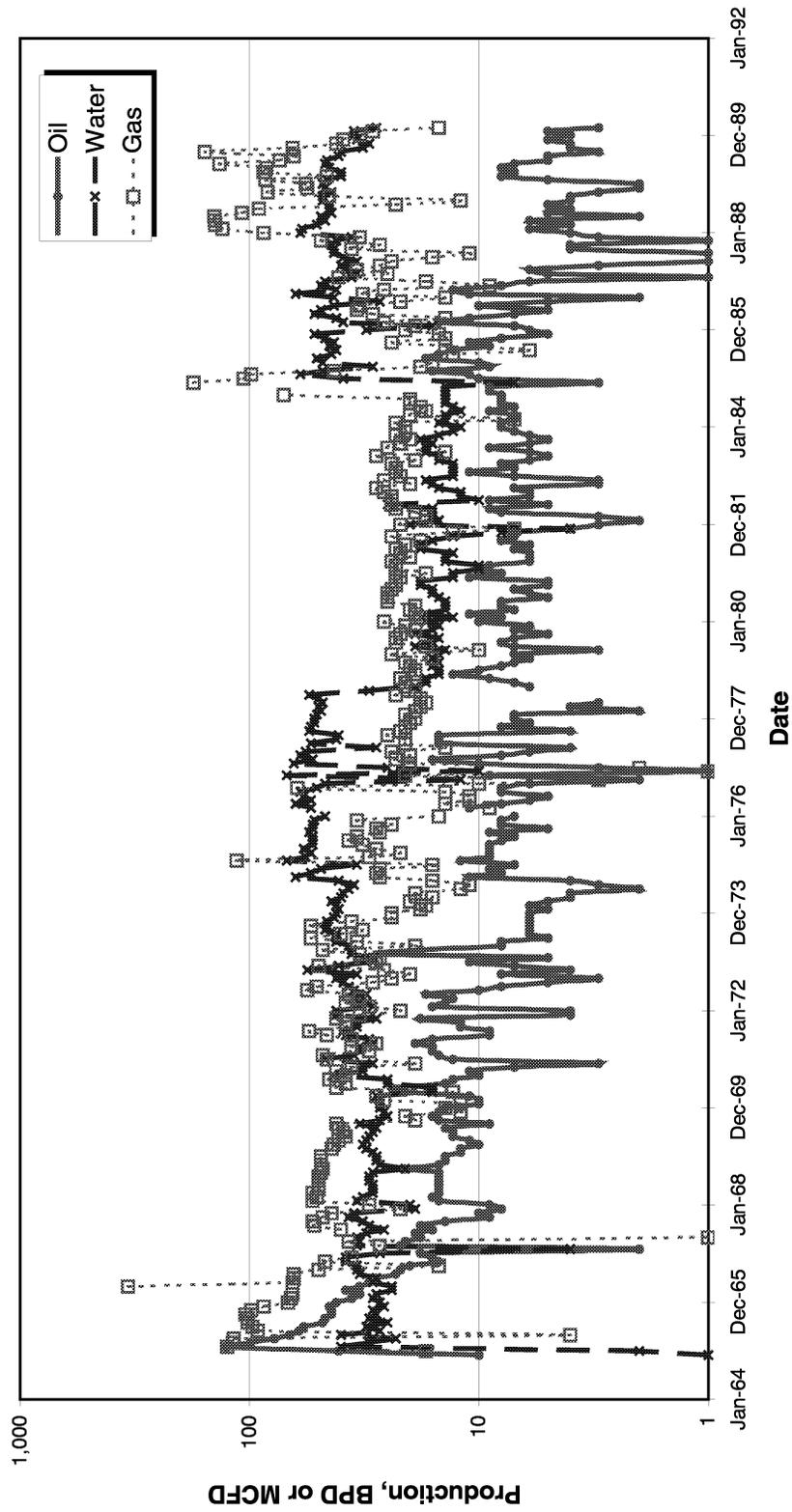


Figure 4-3

**Railroad Gap Field  
Antelope Shale Zone Producer 354-15Z**

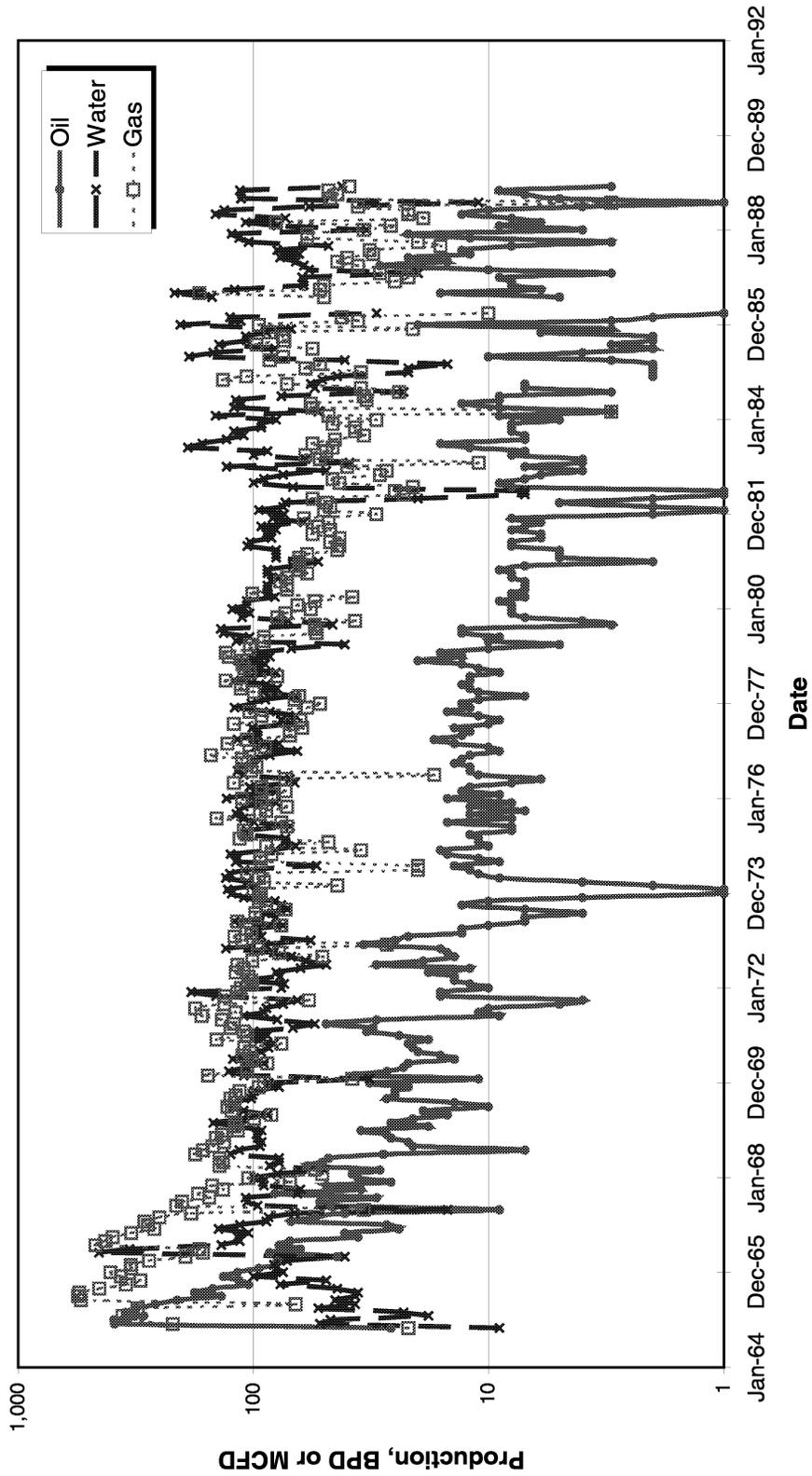
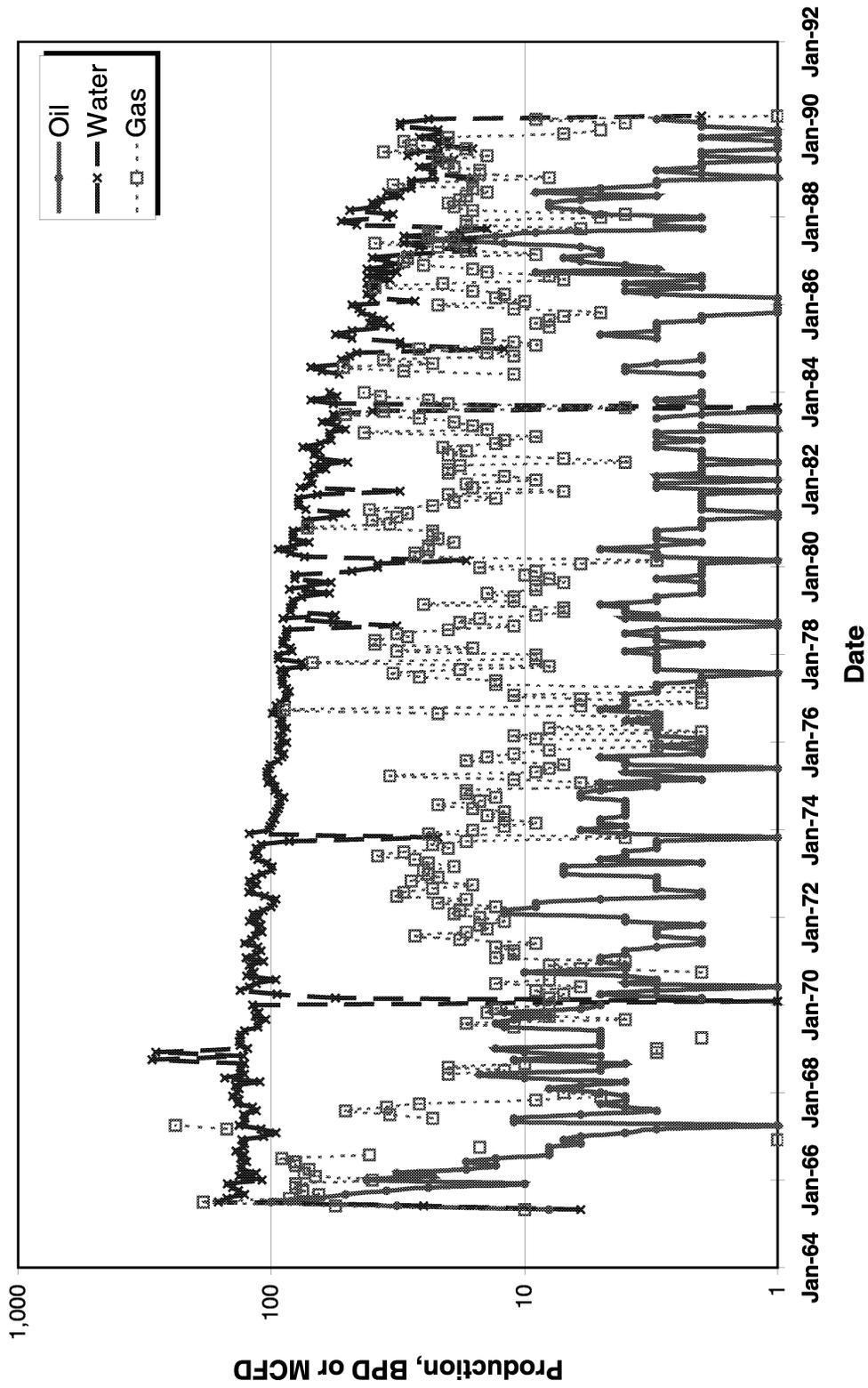


Figure 4-4

### Railroad Gap Field Antelope Shale Zone Well 388-15Z



## **APPENDIX 5 – Correspondence**





**Naftex Operating Company**  
1387 Avenue of the Stars, Suite 202  
Los Angeles, California 90087  
phone 310.2729004  
fax 310.2728877  
e-mail naftex@earthlink.net

March 10, 2000

Mr. Tom Goff, P.E.  
Permit Services Manager  
San Joaquin Valley Unified Air Pollution Control District  
2700 M Street, Suite 275  
Bakersfield, California 93301-2370

**Re: Naftex Operating Company**  
**Request for Experimental Research Exemption**

Dear Mr. Goff:

Naftex Operating Company (Naftex) is applying for an exemption from Rule 2010 (permits required) for an Experimental Research Operation as provided for in District Rule 2021.

Project Description

Naftex has obtained funding from the U.S. Department of Energy (DOE) to evaluate the potential of increasing oil production in the Antelope Shale formation of the Railroad Gap Oilfield by the injection of flue gas. The project will evaluate the potential of flue gas injection an effective method of CO<sub>2</sub> injection. Naftex estimates that a very minor amount of the 7 billion barrels of oil reserves in the Antelope Shale formation have been recovered due to the low efficiencies of other methods of enhanced oil recovery (EOR).

The research operation will be conducted by injecting the exhaust gas from three unpermitted natural gas fired engines, totaling approximately 500 hp, into the formation. The research operation will be conducted in the NW ¼ of Section 15Z, T30S, R22E, MDBM.

Definition for Experimental Research Operation

The definition of Experimental Research Operations in Rule 2021, Section 3.0 includes technology or any industrial process or technology with reduced emissions which is:

- 3.1.1 *Innovative,*
- 3.1.2 *Not in common use for a particular process,*
- 3.1.3 *Not readily available from a commercial supplier, or*
- 3.1.5 *Funded as original research by a public agency*

Naftex's evaluation will have reduced emissions because the exhaust from the engine will be injected into the subsurface formation. This type of CO<sub>2</sub> injection is not in common use and

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is being evaluated as an innovative, low cost alternative to conventional CO<sub>2</sub> injection methods and other EOR technologies. Additionally, the research is funded by the DOE. Attached is a brief project description prepared by NafTex together with evidence of the DOE's award of financial assistance. Therefore, NafTex's project meets the rule definition of Experimental Research Operation.

Requirements of Experimental Research Operations

The requirements of Experimental Research Operations are identified in Section 4.0 of Rule 2021. These operations may be exempted from the requirements of Rule 2010 (Permits Required) if all the following conditions are met.

- 4.1 *The purpose of the operations is to permit investigation, experimentation or research to advance the state of knowledge or state of art of a particular control technology or industrial process;*

NafTex will be investigating the injection of exhaust gas to advance the state of knowledge of EOR by an innovative method of CO<sub>2</sub> injection. EOR is an industrial process; therefore, this requirement is satisfied.

- 4.2 *The APCO is notified in writing of the purpose, goals and objectives of the project and measures are taken to minimize the emission of air contaminants, the proposed installation date, the planned start-up date, the expected duration of the test, and test schedules and the amount and duration of emissions shall be minimal as determined by the APCO;*

This letter notifies the APCO of the purpose, goals and objectives of the project. The proposed startup date is April 1, 2000 and the project will continue for approximately 6 months. The amount of emissions to atmosphere will be minimal because all exhaust gas will be injected into the subsurface formation.

- 4.3 *The cumulative total days of operation shall not exceed 180 calendar days. If the applicant intends to continue operation of the technology or process for more than 180 days, a compliance schedule for obtaining necessary permits under Regulation II (Permits) shall be established by the APCO;*

NafTex's research is not expected to exceed a total of 180 cumulative calendar days. A compliance schedule will be submitted if NafTex desires to extend the operation.

- 4.4 *Official test result (if the project involves air pollution control devices) shall be*

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*submitted to the District, in writing and in final form, no more than 60 days after each test sequence is complete;*

The proposed operation does not involve air pollution control equipment. Therefore, this section is not applicable.

*4.5 The APCO shall have granted prior written approval.*

The purpose of this letter is to obtain written APCO approval. Naflex is requesting an expedient review of this project in order to meet the anticipated startup date of April 1, 2000.

If you have any questions please contact me at (310) 277-9004 or Bob Langner of WZI Inc. at (661) 326-1112.

Sincerely,

A handwritten signature in cursive script, appearing to read "Hormoz Ameri".

Hormoz Ameri  
President

HA/lf  
Enclosure

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San Joaquin Valley  
Air Pollution Control District

March 23, 2000

Naftex Operating Company  
Attn: Mr. Hormoz Ameri  
1801 Ave of the Stars, Suite 302  
Los Angeles, CA 90067

**Re: Request for Experimental Research Exemption**

Dear Mr. Ameri:

The District has received your March 10, 2000 request for permit exemption pursuant to Rule 2021 for testing of a method for increasing oil production by injecting exhaust gas from three unpermitted gas fired IC engines into the Antelope Shale formation.

Following a review of your proposal, the District has determined the requested test does not meet the Rule 2021 definition of an experimental research operation any air pollution control device or technology or any industrial process or technology with reduced emissions. The purpose of this project is to enhance oil production in areas where oil cannot be produced. If successful, this experiment will result in additional oil being produced over a longer period of time. This extra oil production will be accompanied by additional air contaminant emissions that would not occur if this technique was not available. Therefore, this experiment does not qualify for permit exemption as it is not a process expected to result in lower emissions than processes currently in use. Therefore, an Authority to Construct (ATC) to modify existing equipment is required for this operation and the IC engines. Enclosed for your use is an ATC application form and instructions.

Thank you for your cooperation in this matter. Should you have any questions, please contact Mr. John Ludwick of Permit Services at (661) 326-6966.

Sincerely,

Seyed Sadredin  
Director of Permit Services

Thomas E. Goff, P.E.  
Permit Services Manager

jjl  
Enclosures

David L. Crow  
Executive Director/Air Pollution Control Officer

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Northern Region Office  
4230 Kieman Avenue, Suite 130  
Modesto, CA 95356-9321  
(209) 557-6400 • FAX (209) 557-6475

Central Region Office  
1990 East Gettysburg Avenue  
Fresno, CA 93726-0244  
(559) 230-6000 • FAX (559) 230-6061

Southern Region Office  
2700 M Street, Suite 275  
Bakersfield, CA 93301-2370  
(661) 326-6900 • FAX (661) 326-6985

# San Joaquin Valley Air Pollution Control District

## Permit Application Form

### APPLICATION FOR:

- AUTHORITY TO CONSTRUCT (ATC) - New Emission Unit.
- AUTHORITY TO CONSTRUCT (ATC) - Modification Of Emission Unit With Valid PTO/Valid ATC.
- AUTHORITY TO CONSTRUCT (ATC) - Renewal of Valid Authority to Construct.
- PERMIT TO OPERATE (PTO) - Existing Emission Unit Now Requiring a Permit to Operate.

1. PERMIT TO BE ISSUED TO:		
2. MAILING ADDRESS: STREET/P.O. BOX: _____		
CITY: _____	STATE: _____	9-DIGIT ZIP CODE: _____
3. LOCATION WHERE THE EQUIPMENT WILL BE OPERATED: STREET: _____ CITY: _____		WITHIN 1000 FT OF A SCHOOL? <input type="checkbox"/> YES <input type="checkbox"/> NO S.I.C. CODE(S) OF FACILITY (If known): _____ INSTALL DATE: _____
_____ 1/4 SECTION _____ TOWNSHIP _____ RANGE _____		
4. GENERAL NATURE OF BUSINESS: _____		
5. DESCRIPTION OF EQUIPMENT OR MODIFICATION FOR WHICH APPLICATION IS MADE (include Permit Nos., if known, and use additional sheets if necessary):          		
6. HAVE YOU EVER APPLIED FOR AN ATC OR PTO IN THE PAST?	<input type="checkbox"/> YES: ATC/PTO <input type="checkbox"/> NO If yes, #: _____	<b>Optional Section</b> 9. CHECK WHETHER YOU ARE A PARTICIPANT IN EITHER OF THESE VOLUNTARY PROGRAMS: "SPARE THE AIR"  <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Send info "INSPECT"  <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Send info
7. IS THIS PROPERTY ZONED PROPERLY FOR THE PROPOSED USE?	<input type="checkbox"/> YES <input type="checkbox"/> NO	
8. IS THIS APPLICATION SUBMITTED AS A RESULT OF A NOV/NTC?	<input type="checkbox"/> YES: NOV/NTC <input type="checkbox"/> NO If yes, #: _____	
10. SIGNATURE OF APPLICANT: _____		TITLE OF APPLICANT: _____
11. TYPE OR PRINT NAME OF APPLICANT: _____		DATE: _____ PHONE #: ( ) _____ FAX #: ( ) _____

**FOR APCD USE ONLY:**

DATE STAMP	FILING FEE RECEIVED: \$ _____  DATE PAID: _____  PROJECT NO.: _____ FACILITY ID.: _____
------------	---

Northern Regional Office \* 4230 Kieman Avenue, Suite 130 \* Modesto, California 95356-9321 \* (209) 557-6400 \* FAX (209) 557-6475  
 Central Regional Office \* 1990 East Gettysburg Avenue \* Fresno, California 93726-0244 \* (559) 230-5900 \* FAX (559) 230-6061  
 Southern Regional Office \* 2700 M Street, Suite 275 \* Bakersfield, California 93301-2370 \* (661) 326-6900 \* FAX (661) 326-6985

**APPLICATION FOR  
AUTHORITY TO CONSTRUCT AND PERMIT TO OPERATE**

**-INSTRUCTIONS-**

- A. Mark the appropriate box to indicate whether the application is for: an Authority to Construct (ATC) for a new emissions unit; an ATC for a modification to an emissions unit which has a valid Permit to Operate (PTO) or a valid ATC; an ATC for the renewal of a valid ATC; or a PTO for an existing emissions unit which now requires a permit due to loss of exemption from permit.
- B. A nonrefundable filing fee of \$60 is required for each emissions unit which will be issued a permit. An emissions unit is any distinct process which 1) consists of the aggregation of equipment items operating together to perform a given function; and 2) has the potential to cause the emission of an air contaminant. An emissions unit may consist of a single piece of equipment or multiple pieces of equipment, and includes any associated air pollution control equipment. If you do not know the total number of emissions units, the District will determine that for you and send a bill for the appropriate fee. Checks or money orders shall be made payable to the SJVUAPCD.
- C. **Line 1.** Indicate the name of the business exactly as it should appear on the Authority to Construct and on the Permit to Operate.
- D. **Line 2.** List the mailing address where correspondence regarding the application and billing for the Permit to Operate annual fee may be sent. Please include your nine digit zip code.
- E. **Line 3.** List the physical location where the emissions unit(s) will be operated. If a street address is not applicable, provide the United States Geological Survey (USGS) quarter-section, township, and range or the Universal Transverse Mercator (UTM) coordinates. Indicate whether the property is located within 1,000 ft. of the property boundary of a school. Identify the nearest school by name and address. List any standard industrial classification (SIC) code(s) which apply for the facility (if known). If the application is for a Permit to Operate for an existing emissions unit which is now subject to permit requirements due to loss of exemption, then indicate the date that the emission unit was installed at the facility. If the application is for an Authority to Construct for a new emissions unit, then indicate the expected date of installation of the proposed equipment.
- F. **Line 4.** Indicate the general nature of the business performed by the facility.
- G. **Line 5.** For each emissions unit, state the make, model, size, type, and serial number of the entire emissions unit or of its major components. Information must be provided for all pieces of equipment comprising each emissions unit. Identify the applicable permit number for each emissions unit which has either a valid Permit to Operate or a valid Authority to Construct. Attach additional sheets if necessary.
- H. **Line 6.** Indicate whether you have ever applied for an ATC or PTO for any facility within the geographic boundary of the SJVUAPCD in the past. If yes, list the ATC or PTO No(s).
- I. **Line 7.** Indicate whether operation of the proposed emissions unit(s) at the location identified in Line 3 is consistent with the current zoning laws affecting that parcel. Questions regarding zoning

laws and use permits should be addressed to the local city and/or county building and planning departments.

- J. **Line 8.** Indicate whether submission of this application is a result of a Notice of Violation (NOV) or a Notice to Comply (NTC) having been issued to the facility by Air Pollution Control District personnel. If yes, state the number listed on the NOV/NTC.
- K. **Line 9.** This section is optional. Please check whether your organization is a Spare the Air partner, or an INSPECT participant. For more information on either of these programs, please check the appropriate box, or call the District at (209) 497-1000.
- L. **Line 10.** Sign the application in ink. Type or print the title of the person signing as the applicant.
- M. **Line 11.** Type or print the name of the applicant. The applicant must be an officer of the business who will be responsible for complying with all conditions of the Authority to Construct and the Permit to Operate. Indicate the date and the daytime telephone and FAX numbers of the applicant.
- N. **Supplemental Information Required With Each Application.** The following data, specifications, plans, and drawings must be submitted with each application for Authority to Construct and Permit to Operate:
  - 1. **Equipment Location Drawing or Plot Plan** - The drawing or sketch submitted should be to scale and must show the following:
    - a. The property involved and outlines of all buildings and structures on it. Identify all property lines plainly.
    - b. The location and identification of the proposed emissions unit(s) on the property.
    - c. Location of the property with respect to streets and all adjacent properties. Identify adjacent properties. Show the location of all buildings outside of the property that are within 150 feet of the emissions unit. Identify all such buildings (i.e. residence, apartment building, warehouse, retail store, etc.), specifying the height (in feet or number of stories) of each building. Indicate the direction north on the drawing.
  - 2. **Equipment Description** - For each emissions unit, state the make, model, size, type, and serial number of the entire emissions unit or of its major components. Information must be provided for all individual pieces of equipment comprising each emissions unit. List all electric motor horsepower ratings associated with all equipment.
  - 3. **Description of Operation** - The application must be accompanied by a written description of each operation to be carried out in the process. The descriptions must be complete and in detail for all operations. Particular attention must be given to parts of the process which may result in the emission of air contaminants. All obtainable data must be supplied concerning the nature, volumes, particle sizes, weights, and concentrations of all types of air contaminants that may be discharged at each stage in the process. Similarly, the operation of air pollution control equipment must be described in sufficient detail to allow

the District to determine if the process can be expected to consistently operate at the required control efficiencies.

4. **Expected Emission of Air Contaminants** - Submit calculated estimates of the emission of all air contaminants from the proposed equipment, including reference to the source of emission factors. If applicable, include any test data which was collected and analyzed by independent laboratories and used to support the calculations.
5. **Operating Schedule** - Specify the maximum and the average number of hours per day, days per week, and weeks per year that the emissions unit(s) will be operated.
6. **Process Weight** - Detail the type and the total weight of each material consumed or processed by each emissions unit on the basis of pounds per hour or some other mass per unit time which most accurately provides a mechanism to quantify emissions. The Authority to Construct and the Permit to Operate may list conditions which limit the process weight to the quantity specified in the application.
7. **Fuels and Burners Used** - Provide the following information:
  - a. **Gaseous Fuels** - Type, source, heating value, sulfur content (both total and as H<sub>2</sub>S), the amount of excess combustion air (%) utilized, and cubic feet per hour.
  - b. **Liquid Fuels** - Type, source, heating value, sulfur content, nitrogen content, API gravity (degrees), preheat temperature, the temperature at which the SSU viscosity is 150, the type of atomization (steam, air, or mechanical), the amount of excess combustion air (%) utilized, and gallons per hour.
  - c. **Solid Fuels** - Type, source, heating value, sulfur content, nitrogen content, ash content, the amount of excess combustion air (%) utilized, and pounds per hour.

For all burners, indicate the make, model, size (MMBTU/hr.), type, number of burners, and the capacity range of each burner from the minimum to the maximum rate of heat input.

8. **Process and Instrumentation Flow Diagram** - For continuous processes, show the flow of materials and the location and type of all instrumentation, including any stack gas monitors. Show all pertinent temperatures, pressures, volumetric flow rates and mass flow rates.
9. **Equipment Drawings** - Provide drawings, dimensioned and to scale, in plan, elevations and as many sections as are needed to clearly illustrate the design and operation of the emissions unit(s) and the means by which air contaminants are controlled. When standard commercial equipment will be utilized for part of all of an emissions unit, the manufacturer's catalogue describing the equipment may be submitted. Information not contained in the catalogue must be provided by the applicant.

Applications may be submitted either by mail or in person at the following locations. The District is pleased to provide small businesses with assistance in all aspects of the permitting process. Any small

business is welcome to call the **Small Business Assistance (SBA) Hotline** or to visit the **Small Business Assistance Office** located in each of the regional offices. No appointment is necessary. For information, please call the **SBA Hotline** serving the county in which your business is located.

**Northern Regional Office** (Serving San Joaquin, Stanislaus, and Merced Counties):

4230 Kiernan Avenue, Suite 130  
Modesto, California 95356-9321  
(209) 557-6400  
FAX: (209) 557-6475  
SBA Hotline: (209) 557-6457

**Central Regional Office** (Serving Madera, Fresno, and Kings Counties):

1990 E. Gettysburg Avenue  
Fresno, California 93726  
(559) 230-6000  
FAX: (559) 230-6061  
SBA Hotline: (559) 230-5888

**Southern Regional Office** (Serving Tulare and Kern Counties):

2700 "M" Street, Suite 275  
Bakersfield, California 93301-2370  
(661) 326-6000  
FAX: (661) 326-6985  
SBA Hotline: (661) 326-6969

**San Joaquin Valley Unified Air Pollution Control District  
Supplemental Application Form  
LIQUID FUELED  
INTERNAL COMBUSTION ENGINES**

*This form must be accompanied by a completed Application for Authority to Construct and Permit to Operate form.*

PERMIT TO BE ISSUED TO:
LOCATION WHERE THE EQUIPMENT WILL BE OPERATED:

**PROCESS DESCRIPTION**

<b>Type of Use</b>	<input type="checkbox"/> Full Time (not limited to any operating schedule) <input type="checkbox"/> Low Use (limited to < 1000 hrs/yr for all operation, including maintenance and testing) <input type="checkbox"/> Standby Emergency (limited to non-utility electric power generation or other emergency use as approved by the APCO, except for up to 200 hrs/yr for maintenance and testing) Will this equipment be used in an electric utility rate reduction program? <input type="checkbox"/> YES <input type="checkbox"/> NO
<b>Process Data</b>	Process the Engine Serves: _____ Generator Make and Model: _____ Power Output: _____ kW

**EQUIPMENT DESCRIPTION**

<b>Engine Data</b>	Manufacturer: _____	Number of Cylinders: _____
	Model Number: _____	Serial Number: _____
	Maximum Rated Power Output _____ BHP	
	Type: <input type="checkbox"/> Diesel <input type="checkbox"/> Gasoline <input type="checkbox"/> Other (please specify): _____	
<b>Fuel Data</b>	Higher Heating Value: _____ BTU/gal	Sulfur Content: _____ % by Weight
	Fuel Consumption at Rated Output: _____ gals/hr	Fuel Flow Meter? <input type="checkbox"/> YES <input type="checkbox"/> NO
<b>Engine Design and Emission Control Equipment: (Check all applicable boxes)</b>		
	<input type="checkbox"/> Turbocharger	
	<input type="checkbox"/> Intercooler/Aftercooler	
	<input type="checkbox"/> Injection Timing Retarded Relative to Standard Timing:	_____ degrees
	<input type="checkbox"/> Positive Crankcase Ventilation System	
	<input type="checkbox"/> Exhaust Particulate Control Device: Specify what type _____	
	<input type="checkbox"/> Oxidation Catalyst (VOC & CO Reduction) _____ % VOC control _____ % CO control	
	<input type="checkbox"/> Reduction Catalyst (NOx Reduction) _____ % NOx control	
	<input type="checkbox"/> Other (please specify): _____	

*Please Continue on Reverse Side*

*SA-5b 2/98*

Exhaust Emission Data (at maximum rated power output) (If corrected to other than 15% O <sub>2</sub> dry basis, indicate at right)		O <sub>2</sub> , dry:	%
Nitrogen Oxides (as NO <sub>x</sub> )	ppmvd		g/BHP-hr
Carbon Monoxide	ppmvd		g/BHP-hr
Volatile Organic Compounds (as CH <sub>4</sub> )	ppmvd		g/BHP-hr
Particulate Matter Emissions	gr/dscf		g/BHP-hr
Sulfur Oxides (as SO <sub>x</sub> )	ppmvd		g/BHP-hr
Source of Emission Factor:	<input type="checkbox"/> Emission Tests <input type="checkbox"/> Manufacturer's Guarantee <input type="checkbox"/> Other:		

### ADDITIONAL INFORMATION

- Normal Operating Schedule: (for emergency equipment, identify normal testing and maintenance schedule)  
Hours per day \_\_\_\_\_ Days per week \_\_\_\_\_ Weeks per year.
- Nearest Receptor:  
Distance to nearest Residence<sup>1</sup> \_\_\_\_\_ feet  
Distance to nearest Business<sup>2</sup> \_\_\_\_\_ feet  
<sup>1</sup> Examples of Residences includes apartments, houses, dormitories, etc.  
<sup>2</sup> Examples of Businesses includes office buildings, guard posts, factories, etc.
- Stack Parameters: Height \_\_\_\_\_ feet      Inside diameter \_\_\_\_\_ inches  
Exhaust temperature \_\_\_\_\_ °F      Stack gas flow rate \_\_\_\_\_ dscfm  
Is a rain cap (not a flapper) present on exhaust stack?     Yes     No  
Direction of exhaust from structure or device:     Vertical     Horizontal
- Facility Location:     Urban (area of dense population)     Rural (area of sparse population)
- If available, include the manufacturer's specifications of the engine and documented exhaust emissions data for the proposed engine.



