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GEOTHERMAL RESERVOIR WELL STIMULATION
PROGRAM: TECHNOLOGY TRANSFER, VOLUME 2

May 1980

Work Performed Under Contract No. AC32-79AL10563

Republic Geothermal, Inc.
Santa Fe Springs, California

U. S. DEPARTMENT OF ENERGY
Geothermal Energy

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GEOHERMAL RESERVOIR WELL
STIMULATION PROGRAM

TECHNOLOGY TRANSFER

VOLUME II

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TECHNOLOGY TRANSFER

1.0 Introduction

The objective of this phase of the project is to assess the stimulation technology developed in the oil and gas industry as to its applicability to the unique problems of geothermal well stimulation. To accomplish this assessment, we performed a literature search through on-line computer search systems which identified key technical papers. In addition, we met privately with oil and gas operators and service companies to obtain field records of well stimulation programs that have worked successfully. The results of these surveys are documented in the following sections of this chapter.

2.0 Basic Hydraulic Fracturing Publications

The fundamentals of hydraulic fracturing are covered in reference (1) and it is not the intent of this section to review the entire subject. There are, however, four papers worthy of mention because most fracture designs are based on the results of one or more of these papers. They are:

- A. Perkins, T. K. and Kern, L. R.: "Widths of Hydraulic Fractures," Journal of Petroleum Technology, September 1961, p. 937
- B. Geertsma, J. and DeKlerk, F.: "A Rapid Method of Predicting Width and Extent of Hydraulically Induced Fractures," Journal of Petroleum Technology, December 1969, p. 1571.
- C. Nordgren, R. P.: "Propagation of A Vertical Hydraulic Fracture," Society of Petroleum Engineering Journal, August 1972, p. 306.
- D. Daneshy, A. A.: "On The Design of Vertical Hydraulic Fractures," Journal of Petroleum Technology, January 1973, p. 83.

These theories, while not perfect, give engineering rationale for designing a well stimulation treatment. They differ by how each author mathematically modeled the fracture mechanics. Geertsma and Haafkens (2) give an excellent comparison of these four theories.

A hydraulic fracture treatment design predicts the:

- . flow rate
- . duration of treatment
- . fluid type and volume
- . proppant size and type
- . fluid/proppant mixture

required to create a fracture area and prop it. Crack width is important during the treatment in order to allow the sand into the crack, to distribute proppant within the created fracture and to keep the operation from sanding out or plugging. A treatment design can be developed from tables such as given in reference (3) or from computer programs. Designs tables and computer programs are based on one of the four basic theories listed above.

According to each theory, temperature is treated as a constant throughout the fracture and herein lies the weakness of the present state of the art of predicting crack growth. The choice of the fracturing fluid temperature has a large affect on predicted crack width and length as well as proppant distribution within the fracture. Whitsitt and Dysant illustrate the affect of choosing three different temperatures on predicted crack area.

"Three temperatures are chosen--200°F (assumed bottom-hole temperature), 80°F (assumed temperature of fluid at the surface), and 145°F (about average fluid temperature

in the fracture during the stimulation job) to show the influence of temperature on the treatment design calculations. Calculated results are illustrated in Table 1, in which temperature comparisons are made for a stimulation job after 10,000 and 40,000 gal have been pumped."

TABLE 1
EFFECT OF TEMPERATURE ON FRACTURING

Fluid Pumped (1,000 gal)	Temperature (°F)	Viscosity (cp)	Fracture Dimensions			
			Width (in)	Length (ft)	Area (sq ft)	Volume (cu ft)
10	200	4.0	0.101	312	62,489	526
10	145	9.0	0.121	293	58,625	591
10	80	27.6	0.154	265	53,045	681
40	200	4.0	0.128	711	142,188	1,517
40	145	9.0	0.154	678	135,636	1,741
40	80	27.6	0.199	628	125,621	2,083

Pumping rate - 40 bpm
 Combined "C" - $0.002 \text{ ft}/(\text{min})^{\frac{1}{2}}$
 Spurt Loss - 5.00 cc
 Fracture Height 100 ft

"The fracture width is about 20 percent greater for the 145°F case than for the 200°F case. Therefore, if in predicting fracture width the fluid properties are evaluated at bottom-hole temperature conditions, the width is considerably underestimated. As a result, an opportunity to use a higher proppant concentration or larger proppants that could give higher fracture conductivities may be missed, and the maximum available production increase from the treatment job could be lost."

"On the other hand, if the fluid properties are evaluated at surface temperature conditions, the fracture will appear to be much wider (up to 50 percent) than it actually is. As a result, proppants may be used that are too large for the fracture, or too high a proppant concentration may be pumped. Under these conditions it is likely that a premature proppant screenout may occur, causing an unsuccessful stimulation job."

"These calculations show that fracture area decreases as fluid temperature declines even though fracture volume increases."

"In this example, the combined fluid loss coefficient was assumed constant. If temperature effects on this coefficient had been taken into account, the noted changes in fracture width would have been more pronounced."

It is common practice to use the average fluid temperature in the fracture when calculating fracture geometry on fractures having bottom-hole temperatures up to 300°F. This practice is probably realistic for geothermal well fracturing designs provided the fracturing fluid viscosity is not highly sensitive to temperature. If experience with geothermal wells indicates this design practice does not predict reasonable fracture geometries, present theory should be extended to account for viscosity and leak off effects caused by temperature variations within the fracture.

The effect of variations in temperature and viscosity within the fracture volume are explained more fully by:

- A. Wheeler, J. A.: "Analytical Calculations of Heat Transfer from Fractures," Paper SPE 2494 presented at SPE Improved Oil Recovery Symposium, Tulsa, OK, April 13-15, 1969.
- B. Whitsitt, N. F. and Dysart, G. R.: "The Effect of Temperature on Stimulation Design," Journal of Petroleum Technology, April 1970, p. 493.
- C. Sinclair, A. Richard: "Heat Transfer Effects in Deep Well Fracturing," Journal of Petroleum Technology, December 1971, p. 1634.

Temperature effects spelled out by these authors are:

- . The "c" factor used to calculate fracture area should be evaluated at a viscosity equivalent to that at the average fracture temperature or evaluated continuously over small segments of the fracture length.
- . Lower temperatures (and thus higher viscosity) near the wellbore cause much lower proppant settling rates than will be found farther out in the fracture where temperatures are higher.
- . Fracture width will increase from wellbore to the fracture tip.
- . In most equations describing dynamic fracture growth, the viscosity of the fracturing fluid is assumed to be constant at reservoir temperature during the fracturing treatment. This is like assuming that fluid entering the fracture comes instantly to reservoir temperature. Temperature profiles show that much of the fluid in the fracture is below reservoir temperature and consequently has a lower temperature and a higher viscosity than has been previously assumed.

Equations that describe fracture growth are affected in two ways by heat transfer and heat blockage:

- (a) fluid-loss calculations depend on the effective leakoff viscosity
- (b) convective heat blockage allows the fluid in the fracture to retain a viscosity which is many times what it would be at reservoir temperature

3.0 Computer Programs

Three computer have been written for this project.
Each are discussed below.

Geertsma and Deklerk: The paper (4) by those two authors is the basis of one method of hydraulic fracture designs that is commonly used in the petroleum industry. Their fracture propagation model is based on a simple geometrical fracture-extension as shown in Figure 1.

Schematic representation of linearly propagating fracture
with laminar fluid flow according to Geertsma and De Klerk

Figure 1

The fracture has a fixed height H . The cross sectional area perpendicular to the direction of fracture propagation is rectangular in shape with a constant width $W(x,t)$. The fluid pressure in this cross section is constant and the pressure distribution in the direction of fracture propagation is determined by the Newtonian flow resistance in a narrow rectangular slit.

Geertsma and Deklerk express their solution in terms of dimensionless parameters which are related through two coupled nonlinear algebraic equations. These equations are plotted on a chart and fracture designs are made from this chart. For quick design calculations, however, we have programed their equations so that they are solved numerically giving direct numerical design data. This program is set up on the GE time share system (see Appendix A for the program listing). The program is user oriented and prompts the user for input data. A typical print out is given in Figure 2.

The Geertsma-Deklerk fracture theory assumes constant fluid viscosity or constant temperature throughout the fracture. Normally, heat-transfer theories are used to predict temperature distributions in the fracture and from this temperature profile an average temperature is selected to establish fluid viscosity for the Geertsma-Deklerk fracture calculations.

GEERTSMA 12:130DT 10/19/79

MAXIMUM JOB TIME (MIN)?60

TIME INCREMENT (MIN)?10

INJECTION RATE (BPM)?50

VISCOSITY (CP)?10

FRACTURE HEIGHT (FT)?200

ROCK SHEAR MODULUS (PSI)?2600000

FRACTURING FLUID COEFFICIENT (FT/MIN^{1/2})?.002

SPURT LOSS (FT³/FT²=FT)?0

WIDTH (IN)	LENGTH (FT)	VOLUME (CU FT)	EFF (%)	TIME (MIN)
0.114	267.5	1016.1	36.2	10.0
0.138	392.6	1806.9	32.2	20.0
0.154	490.4	2522.8	30.0	30.0
0.167	573.8	3192.9	28.5	40.0
0.177	647.9	3830.4	27.3	50.0
0.186	715.2	4442.7	26.4	60.0

Typical Computer Print Out

Figure 2

Sinclair: Richard Sinclair's paper (5) shows how fluid temperature varies along a fracture length. He assumes the "leakoff rate" is constant along the fracture and that fracture width and height are known. Local temperature depends on reservoir and fluid temperature at the fracture/wellbore.

The following equations relate the Darcy leakoff velocity to efficiency and are supplemental to the equations in Reference (5). For times from zero to 3 hours, the following equation (Reference 6) is a good approximation for the fracture length as a function of time.

$$L = L_{\max} \left[1 - e^{-\frac{V_f t}{W}} \right]$$

where

L = dynamic fracture length

$L_{\max}$ = maximum fracture length

t = pumping time

V_f = Darcy leakoff velocity

W = fracture width

but

$$2LWH = nQt$$

or

$$L = \frac{nQt}{2WH}$$

where

η = efficiency

Q = flow rate

H = fracture height

Note also that

$$L_{\max} = \frac{Q}{4V_f H}$$

Substitution gives

$$2\eta\left(\frac{V_f t}{W}\right) = 1 - e^{-\left(\frac{V_f t}{W}\right)}$$

which relates efficiency, η , to Darcy velocity, V_f .

The equations in Sinclair's paper were programed (see Appendix A for listing) to give temperature ratio versus distance ratio as in the paper. The program is also set up on the GE time share system and is user oriented as it prompts the user for input. Figure 3 gives typical input-output data.

TEMPAPS 12:090DT 10/19/79

TOTAL INJECTION RATE (BPM) AND EFFICIENCY?50,.2

FRACTURE WIDTH (INCHES) AND HEIGHT (FT)?15,200

TIME, HRS?1.5

THERMAL CONDUCTIVITY OF FORMATION, BTU/HR FT DEGF?1.5

DENSITY OF FRACTURING FLUID AND FORMATION, LB/CU FT?62.4,120

SPECIFIC HEAT OF FRACTURING FLUID AND FORMATION, BTU/LB DEGF?1,.43

DARCY VELOCITY IS 1.34 FT PER DAY

FRACTURE LENGTH IS 335.68 FT

MAXIMUM FRACTURE LENGTH IS 375.67 FT

DISTANCE RATIO	TEMPERATURE RATIO
0.00	0.0000
0.05	0.0727
0.10	0.1521
0.15	0.2378
0.20	0.3286
0.25	0.4229
0.30	0.5186
0.35	0.6129
0.40	0.7026
0.45	0.7842
0.50	0.8543
0.55	0.9104
0.60	0.9513
0.65	0.9775
0.70	0.9917
0.75	0.9978
0.80	0.9996
0.85	1.0000
0.90	1.0000
0.95	1.0000
1.00	1.0000

Typical Computer Input-Output Data for System
Figure 3

Romero-Juarez: This author gives a simplified method for calculating steady state temperature distributions of fluid pumped through downhole tubing. This method assumes that a pumping time of 1 hour is enough for meeting Ramey's (8) steady state, heat-flow approximation in and near the wellbore. This assumption may limit its use in this project. The program listing is given in Appendix A.

4.0 Fracture Stimulation Case Histories

As part of this study, we surveyed the industry to gather field data from actual fracture treatment jobs. Input to this study throughout the industry covers a variety of locations or field conditions. The response indicates a high level of interest in the geothermal fracturing study and we are most appreciative of all who took time from their normal work load to contribute their experience to the project.

A work sheet was prepared on each case history and all work sheets are included in this section for future reference. (Appendix B).

In general, the bottom-hole temperatures were between 200°F and 300°F. Temperature from the various wells agreed with the temperature data (Table 2) given by Whitsitt and Dysart (9).

TABLE 2
DEPTHS OF WELLS THAT HAVE BOTTOM-HOLE TEMPERATURES ABOVE 200°F

<u>Region</u>	<u>Well Depth (ft)</u>
West Texas	10,000 to 16,000
North Central Texas	6,000
East Texas	6,000
Oklahoma and Kansas	8,000 to 15,000
Louisiana and Mississippi	8,000 to 12,000
South Texas	5,500

This broad experience shows that the methods of designing a fracturing program give favorable results in the form of improved production.

Field experience shows that fracturing fluids that are adequate for bottom-hole temperature of 200°F are not adequate for bottom-hole temperatures near 300°F unless special design considerations are taken. New fracture fluids are now being designed for the 300°F to 500°F temperatures and research is continuing to further upgrade fluids to work at these conditions.

Fluids that have worked in the 300^b wells are:

- . Western's - Titan 3
- . BJ Hughes - Krystal Frac Fluid
- . Dowell's - YF 400

For proppants, there are low strength and high strength proppants. Low strength sand is the most widely used; however, sand does crush at closure stresses above 4,000 psi and at higher temperatures above 300°F. In the wells examined here, 20/40 mesh sand is most often used in wells to depths of 10,000 feet. Sintered Bauxite and Super Sand, an uncured resin coated sand, are high strength proppants that are currently available. They retain permeability at high closure stress and high-temperatures. Bauxite is used between the depths of 10 to 18 thousand feet and Super Sand is used between the depths of 2 to 18 thousand feet. Super Sand is unique since it is cohesive and controls sand formation material or proppant flow back from the fracture.

Following the treatment reports of actual case histories of well stimulation, a partial list is included (Appendix C) of all of the people and companies which we tried to contact. Their help was invaluable in assessing the current technology in well stimulation.

5.0 REFERENCES

1. Howard, G. C. and C. R. Fast, Hydraulic Fracturing, SPE Monograph, Vol. 2, 1970
2. Geertsma, J. and R. Haafkens, "A Comparison of the Theories for Predicting Width and Extent of Vertical Hydraulically Induced Fracture," Journal of Energy Resources Technology (ASME), Vol. 101, March 1979.
3. The Frac Book Design/Data Manual, published by Halliburton Services, Duncan, OK, 1971.
4. Geertsma, J. and DeKlerk, F.: "A Rapid Method of Predicting Width and Extent of Hydraulically Induced Fractures," Journal of Petroleum Technology, December 1969, p. 1571.
5. Sinclair, A. Richard: "Heat Transfer Effects in Deep Well Fracturing," Journal of Petroleum Technology, December 1971, p. 1634.
6. Wheeler, J. A.: "Analytical Calculations of Heat Transfer from Fractures," Paper SPE 2494 presented at SPE Improved Oil Recovery Symposium, Tulsa, OK, April 13-15, 1969.
7. Romero-Juárez, A.: "A Simplified Method for Calculating Temperature Changes in Deep Wells," SPE-AIME, Petróleos Mexicanos, June 1979.
8. Ramey, H. J. Jr.: "Wellbore Heat Transmission," Trans., AIME (1962) 225, 427-435.
9. Whitsitt, N. F. and Dysart, G. R.: "The Effect of Temperature on Stimulation Design," Journal of Petroleum Technology, April 1970, p. 493.

6.0 APPENDICES

6.1 APPENDIX A

GEERTSMA 12:14CDT 10/19/79

```

2000THIS PROGRAM IS BASED ON THE GEERTSMA AND DE KLERK METHOD OF PREDICTING
    FRACTURE WIDTH AND LENGTH
210 REAL MT,MU
300 PRINT,"MAXIMUM JOB TIME (MIN)"
305 INPUT, MT
310 PRINT,"TIME INCREMENT (MIN)"
315 INPUT, DT
320 PRINT,"INJECTION RATE (BPM)"
325 INPUT, Q
330 PRINT,"VISCOSITY (CP)"
335 INPUT, MU
340 PRINT,"FRACTURE HEIGHT (FT)"
345 INPUT, FH
350 PRINT,"ROCK SHEAR MODULUS (PSI)"
355 INPUT, G
360 PRINT,"FRACTURING FLUID COEFFICIENT (FT/MIN1/2)"
365 INPUT, C
370 PRINT,"SPURT LOSS (FT3/FT2=FT)"
375 INPUT, SP
380 PRINT 80
385 80 FORMAT(////)
390 PRINT 20
391 20 FORMAT(5X,"WIDTH",4X,"LENGTH",4X,"VOLUME",5X,"EFF",7X,"TIME")
392 PRINT 21
393 21 FORMAT(6X,"(IN)",5X,"(FT)",4X,"(CU FT)",5X,"(%)",6X,"(MIN)",/)
400 K=MT/DT
410 DO 200 J=1,K
420 T=DT*J
510 DKML=8.724*(.00561*Q/(FH*C**2))**3*(145*MU/(G*60*T))
520 DKU=1
521 DKUP=DKU
540 50 CONTINUE
542 IF (SP.EQ.0) A=3.14159
544 IF (SP.EQ.0) GO TO 5
546 DKS=C*SQRT(T)/SP
550 A=3.14159+8*DKU/DKS
552 5 CONTINUE

```



```

560 ARG=8*SQRT(3.14159)*DKU/A
561 IF(ARG.LT.2.) GO TO 10
562 NUM=1
565 ERE=1
567 DO 40 N=1,8
569 NUM=(2*N-1)*NUM
572 ERE=ERE+(-1)**N*NUM/(2*ARG**2)**N
574 40 CONTINUE
576 ERE=ERE/ARG/SQRT(3.14159)
580 DKL=(1-(A/16/DKU)*(1-ERE))/2/3.14159
585 GO TO 11
590 10 CONTINUE
592 ARG2=ARG**2
595 CALL ERFC(ARG,EX,CX)
600 DKL=(1-(A/16/DKU)*(1-EXP(ARG2)*CX))/2/3.14159
605 11 CONTINUE
610 DKU=(1/DKML/DKL/DKL)**.25
620 DDKU=DKU-DKUP
630 DDKU=ABS(DDKU)
635 IF(DDKU.LT..0001) GO TO 100
637 DKUP=DKU
640 GO TO 50
650 100 CONTINUE
660 W=12*C*SQRT(T)/DKU
670 XL=5.61*Q*SQRT(T)*DKL/C/FH
680 VOL=2*W*XL*FH/12
690 EFF=VOL*100/(Q*5.61*T)
740 PRINT 22,W,XL,VOL,EFF,T
750 22 FORMAT(F10.3,2F10.1,F9.1,F11.1)
755 200 CONTINUE
760 PRINT 23
770 23 FORMAT(////)
780 STOP
790 END

```

TEMPARS 12:100DT 10/19/79

```
2000THIS PROGRAM IS BASED ON RICHARD SINCLAIR'S PAPER, "HEAT TRANSFER EFFECTS
    IN DEEP WELL FRACTURING"
210 DIMENSION TEMP(21),RATIO(21)
220 REAL LMAX,LMAX1,L,K,M
230 PRINT,"TOTAL INJECTION RATE (BPM) AND EFFICIENCY"
235 INPUT,Q,EFF
240 PRINT,"FRACTURE WIDTH (INCHES) AND HEIGHT (FT)"
245 INPUT,W,H
250 PRINT,"TIME, HRS"
255 INPUT,T
260 PRINT,"THERMAL CONDUCTIVITY OF FORMATION, BTU/HR FT DEGF"
265 INPUT,K
270 PRINT,"DENSITY OF FRACTURING FLUID AND FORMATION, LB/CU FT"
275 INPUT,RHOF,RHO1
280 PRINT,"SPECIFIC HEAT OF FRACTURING FLUID AND FORMATION, BTU/LB DEGF"
285 INPUT,CF,C1
290 Q=Q*60*24
300 XI=1
310 DXN=.01
320 IF(EFF.EQ.1) GO TO 20
330 10 CONTINUE
340 XNUM=XI*DXN
350 F=EXP(-XNUM)+2*EFF*XNUM-1
360 IF(F.GT.0) GO TO 30
370 XI=XI+1
380 GO TO 10
390 20 XNUM=0
400 30 CONTINUE
402 PRINT 40
403 40 FORMAT(////)
410 VF=2*W*XNUM/T
420 LMAX=1.4025*Q/(VF*H)
430 L=LMAX*(1-EXP(-XNUM))
431 PRINT 41,VF
432 41 FORMAT(1X,"DARCY VELOCITY IS",F6.2,2X,"FT PER DAY",/)
433 PRINT 42,L
434 42 FORMAT(1X,"FRACTURE LENGTH IS",F10.2,2X,"FT",/)
435 PRINT 43,LMAX
436 43 FORMAT(1X,"MAXIMUM FRACTURE LENGTH IS",F10.2,2X,"FT",///)
440 ALPHA=RHOF*CF*VF*H/(2*K*24)
450 TAU=K*T/(H*2*RHO1*C1)
460 M=RHOF*CF*W/(24*RHO1*C1*H)
```

```

461 Q0=0
470 DO 100 I=1,21
480 XI=I-1
490 RATIO(I)=.05*XI
500 X=L*RATIO(I)
510 GAM=X/H
512 Q=Q0+PHOF*CF*5.61/(4*H*K+24)
520 DEL=(1/(2+ALPHA))*ALOG(Q/(Q-2*ALPHA+GAM))
530 RAD=SQRT(TAU-DEL*M)
540 ARG1=DEL/2/RAD+ALPHA*RAD
550 ARG2=DEL/2/RAD-ALPHA*RAD
560 CALL ERFC(ARG1,EX1,DX1)
570 XX1=DX1
580 CALL ERFC(ARG2,EX2,DX2)
590 XX2=DX2
600 TEMP(I)=(Q/(Q-2*ALPHA+GAM))*XX1+XX2)/2
602 TEMP(I)=1-TEMP(I)
610 100 CONTINUE
612 PRINT 110
613 110 FORMAT(7X,"DISTANCE",3X,"TEMPERATURE")
614 PRINT 111
615 111 FORMAT(9X,"RATIO",7X,"RATIO",/)
620 DO 200 J=1,21
630 PRINT 150, RATIO(J),TEMP(J)
640 150 FORMAT(F13.2,F14.4)
650 200 CONTINUE
652 PRINT 210
654 210 FORMAT(////)
660 STOP;END

```

SIMTEM 12:160DT 10/19/79

```
1000THIS PROGRAM IS BASED ON, "A SIMPLIFIED METHOD FOR CALCULATING TEMPERATURE
    CHANGES IN DEEP WELLS", BY A. ROMERO-JURPEZ
110 DIMENSION ZZ(200),T(200),TG(200)
150 PRINT,"TUBING ID,OD, AND CASING ID (INCHES)"
160 INPUT,DTI,DTE,DCI
170 PRINT,"WELL DEPTH (FT) AND INJECTION RATE (BPM)"
180 INPUT,WD,SI
182 SI=SI*60*24
190 PRINT,"GEOTHERMAL GRADIENT (DEG F/FT) AND TIME FUNCTION"
200 INPUT,GE,SFT
210 PRINT,"FORMATION AND FLUID TEMPERATURES AT SURFACE (DEG F)"
220 INPUT,TES,TFS
250 BETA=.281*DTI/(DCI-DTE)
260 F=1.658*(1+BETA*SFT)/BETA
270 A=F*SI
300 Z=0
310 DZ=500
320 I=1
350 100 CONTINUE
355 ZZ(I)=Z
360 IF(Z.GE.WD) Z=WD
370 TG(I)=GE*Z+TES
380 T(I)=GE*Z+TES-GE*A+(TFS+GE*A-TES)*EXP(-Z/A)
390 IF(Z.EQ.WD) GO TO 110
400 I=I+1
410 Z=Z+DZ
420 GO TO 100
430 110 CONTINUE
440 PRINT 150
442 150 FORMAT(////,5X,"HOLE",6X,"FLUID",4X,"FORMATION")
445 PRINT 155
450 155 FORMAT(4X,"DEPTH",6X,"TEMP",6X,"TEMP")
455 PRINT 160
460 160 FORMAT(6X,"FT",7X,"DEG F",5X,"DEG F",/)
500 DO 200 K=1,I
510 PRINT 120, ZZ(K),T(K),TG(K)
520 120 FORMAT(F10.0,2F10.2)
530 200 CONTINUE
540 PRINT 210
550 210 FORMAT(////)
560 STOP;END
```

6.2 APPENDIX B

DATA SHEETS

HYDRAULIC FRAC TREATMENTS

COMPANY: Apache
AREA: Anadarko Basin (West Oklahoma, Texas)
DEPTH: 16,000 - 18,000 ft.
TEMPERATURE: 275 - 325°F
INTERVAL: 20-40 ft.
PERMEABILITY: .1 to .5 md
GAS, OIL, OR OTHER: Gas

TYPE TREATMENT:

VOLUME OF TREATMENT: 50,000 gal.

RATE: 12-15 BPM

TYPE OF FLUID: Western (Titan 3) and B.J. (Krystal)

TYPE OF PROPPANT: Sintered Bauxite

AMOUNT OF PROPPANT: 50,000 lbs.

AVG (lb/gal)

SLUGS ? (Y or N)

HIGHEST (lb/gal)

PRE FRAC TESTING (Y or N):

TYPE OF TEST: Simple flow test to evaluate well

POST FRAC TESTING (Y or N):

TYPE OF TEST:

RESULTS: 2 to 4 factor improvement in production

COMMENTS:

- Fracture gradient .93-.95 psi/ft up to .97 psi/ft.
- Not using guar based fluids anymore because these fluids break down at high temperature (changed a year ago)
- Mentioned Dowell YF 400 as a new high-temperature fluid.

HYDRAULIC FRAC TREATMENTS

COMPANY: ARCO
AREA: South Texas *
DEPTH:
TEMPERATURE: 275° - 300°F
INTERVAL:
PERMEABILITY:
GAS, OIL, OR OTHER:

TYPE TREATMENT:

VOLUME OF TREATMENT:

RATE:

TYPE OF FLUID:

TYPE OF PROPPANT: Standard Halliburton Fluids

AMOUNT OF PROPPANT: Sintered Bauxite

AVG (lb/gal)

SLUGS ? (Y or N)

HIGHEST (lb/gal)

- cross link gel
- delayed retardation
- methanal additive

PRE FRAC TESTING (Y or N):

TYPE OF TEST:

POST FRAC TESTING (Y or N):

TYPE OF TEST:

RESULTS:

COMMENTS:

* Location and details confidential.

HYDRAULIC FRAC TREATMENTS

COMPANY: Report by BJ Hughes 8/21/79
AREA: Panola County, Texas (Cotton Valley Sand)
DEPTH: [Zone #1 9,128-9,286'] [Zone #2 8,915-8,750']
TEMPERATURE: 242°F
INTERVAL: [Zone #1 125'] [Zone #2 300']
PERMEABILITY:
GAS, OIL, OR OTHER: Gas

TYPE TREATMENT:	(ZONE #1)	(ZONE #2)
VOLUME OF TREATMENT:	410,000 Gal	240,000 Gal
RATE:	35 BPM	
TYPE OF FLUID:	Krystal 50 + CO2	Krystal 50 + CO2
TYPE OF PROPPANT:	20-40 Ottawa Sand	Ottawa Sand
AMOUNT OF PROPPANT:	1,000,000 lbs.	600,000 lbs
	AVG (lb/gal)	
	SLUGS ? (Y or N)	
	HIGHEST (lb/gal)	

PRE FRAC TESTING (Y or N):

TYPE OF TEST:

POST FRAC TESTING (Y or N):

TYPE OF TEST:

RESULTS:

Frac Length

- . Zone #1 1,000'
 - . Zone #2 1,000'
-

COMMENTS:

- . 400 MCF/Day (before)
- . 800 MCF/Day (after)

HYDRAULIC FRAC TREATMENTS

COMPANY: Report by BJ Hughes 8/21/79
AREA: Freestone County, Texas (Cotton Valley Lime)
DEPTH: 11,800' - 11,590'
TEMPERATURE: 287°F
INTERVAL: 210'
PERMEABILITY:
GAS, OIL, OR OTHER: Gas

TYPE TREATMENT:
VOLUME OF TREATMENT: . 220,000 gals Super Krystal 60 + 10% Methanol
RATE: . 100,000 gals Krystal 50 + 5% Methanol
15 BPM
TYPE OF FLUID: . 60,000 lbs 100 Mesh
TYPE OF PROPPANT: . 576,000 lbs 20-40 Ottawa Sand
. 192,000 lbs 20-40 Sintered Bauxite
AMOUNT OF PROPPANT:
AVG (lb/gal)
SLUGS ? (Y or N)
HIGHEST (lb/gal)

PRE FRAC TESTING (Y or N):

TYPE OF TEST:

POST FRAC TESTING (Y or N):

TYPE OF TEST:

RESULTS:

Frac Length - 1,000'

COMMENTS:

. 200 MCF/Day (before)
. 1,100 MCF/Day (after)

HYDRAULIC FRAC TREATMENTS

COMPANY: Report by BJ Hughes 8/21/79
AREA: Freestone County, Texas (Cotton Valley Lime)
DEPTH: 12,532 - 12,330'
TEMPERATURE: 300°F
INTERVAL: 172'
PERMEABILITY:
GAS, OIL, OR OTHER: Gas

TYPE TREATMENT: . 140,000 gal Super Krystal 60 + 10% Methanol
VOLUME OF TREATMENT: . 80,000 gal Krystal 60 + 3% Methanol
RATE: 12 BPM
TYPE OF FLUID:
TYPE OF PROPPANT: . 50,000 lbs 100 Mesh Sand
 . 239,000 lbs 20-40 Ottawa Sand
AMOUNT OF PROPPANT: . 289,000 lbs 20-40 Bauxite
 AVG (lb/gal)
 SLUGS ? (Y or N)
 HIGHEST (lb/gal)

PRE FRAC TESTING (Y or N):
TYPE OF TEST:

POST FRAC TESTING (Y or N):
TYPE OF TEST:

RESULTS:
Frac Length 950'

COMMENTS:
 . 1,000 MCF/Day (before)
 . 4,400 MCF/Day (after)

HYDRAULIC FRAC TREATMENTS

COMPANY: Report by BJ Hughes 8/21/79
AREA: Rusk County, Texas
DEPTH: 10,903'
TEMPERATURE: 270°F
INTERVAL: 300'
PERMEABILITY:
GAS, OIL, OR OTHER:

TYPE TREATMENT:

VOLUME OF TREATMENT: . 120,000 gal Super Krystal 60 + CO2
RATE: 15 BPM . 50,000 gal Krystal 50 + CO2

TYPE OF FLUID:

TYPE OF PROPPANT: . 270,000 lbs 20-40 Ottawa Sand
AMOUNT OF PROPPANT: . 40,000 lbs 20-40 Bauxite

AVG (lb/gal)

SLUGS ? (Y or N)

HIGHEST (lb/gal)

PRE FRAC TESTING (Y or N):

TYPE OF TEST:

POST FRAC TESTING (Y or N):

TYPE OF TEST:

RESULTS:

. 1,100 psi
. 1,100 MCF/Day + 70 BBLS H2O per Day

COMMENTS:

Frac Length - 1,050'

HYDRAULIC FRAC TREATMENTS

COMPANY: Report by BJ Hughes 8/21/79
AREA: Cherokee County, Texas
DEPTH: [Zone #1, 10,801 - 10,850'] [Zone #2, 10,437']
TEMPERATURE: 280°F
INTERVAL: [Zone #1 18'] [Zone #2 50']
PERMEABILITY:
GAS, OIL, OR OTHER:

TYPE TREATMENT:	ZONE #1	ZONE #2
VOLUME OF TREATMENT:	40,000 gals	140,000 gals
RATE:	15 BPM	
TYPE OF FLUID:	Super Krystal 60 + Diesel + CO2	
TYPE OF PROPPANT:	20-40 Ottawa	20-40 Sintered
AMOUNT OF PROPPANT:	102,000 lbs	470,000 lbs
	15,000 Bauxite	5,500 lbs
		20-40 Ottawa
		Sintered Bauxi
AVG (lb/gal)		
SLUGS ? (Y or N)		
HIGHEST (lb/gal)		

PRE FRAC TESTING (Y or N):

TYPE OF TEST:

POST FRAC TESTING (Y or N):

TYPE OF TEST:

RESULTS:

COMMENTS:

Frac Length - [Zone #1, 1,800'] [Zone #2, 1,800']

HYDRAULIC FRAC TREATMENTS

COMPANY: Report By BJ Hughes 8/21/79
AREA: Freestone County, Texas (Travis Peak)
DEPTH: 10,260'
TEMPERATURE: 260°F
INTERVAL:
PERMEABILITY:
GAS, OIL, OR OTHER:

TYPE TREATMENT:
VOLUME OF TREATMENT: 80,000 gals
RATE: 12 BPM
TYPE OF FLUID: Krystal 50
TYPE OF PROPPANT: 20-40 Ottawa Sand
AMOUNT OF PROPPANT: 160,000 lbs
AVG (lb/gal)
SLUGS ? (Y or N)
HIGHEST (lb/gal)

PRE FRAC TESTING (Y or N):
TYPE OF TEST:

POST FRAC TESTING (Y or N):
TYPE OF TEST:

RESULTS:

COMMENTS:

HYDRAULIC FRAC TREATMENTS

COMPANY: Report by BJ Hughes 8/21/79
AREA: Rusk County, Texas
DEPTH: 10,355 - 10,414 '
TEMPERATURE: 262°F
INTERVAL:
PERMEABILITY:
GAS, OIL, OR OTHER:

TYPE TREATMENT: . 20,000 gal Krystal 30 + 5% Diesel
VOLUME OF TREATMENT: . 120,000 gal Super Krystal 60
RATE: 14 BPM . 90,000 gal Krystal 50
TYPE OF FLUID: . 9,025 gal Methanol
TYPE OF PROPPANT: 20-40 Ottawa Sand
AMOUNT OF PROPPANT: 587,500 lbs
AVG (lb/gal)
SLUGS ? (Y or N)
HIGHEST (lb/gal)

PRE FRAC TESTING (Y or N):

TYPE OF TEST:

POST FRAC TESTING (Y or N):

TYPE OF TEST:

RESULTS:

COMMENTS:

HYDRAULIC FRAC TREATMENTS

COMPANY: Report by BJ Hughes 8/21/79
AREA: Harrison County, Texas
DEPTH: 9,950 - 10,036'
TEMPERATURE: 258°F
INTERVAL:
PERMEABILITY:
GAS, OIL, OR OTHER: Gas

TYPE TREATMENT: . 215,000 gal Super Krystal 60 + 5% Diesel + 5% Methanol
VOLUME OF TREATMENT: . 135,000 gal Krystal 60 + 5% Diesel + 5% Methanol
RATE: 20 BPM
TYPE OF FLUID:
TYPE OF PROPPANT: 20-40 Ottawa Sand
AMOUNT OF PROPPANT: 985,000 lbs
AVG (lb/gal)
SLUGS ? (Y or N)
HIGHEST (lb/gal)

PRE FRAC TESTING (Y or N):
TYPE OF TEST:

POST FRAC TESTING (Y or N):
TYPE OF TEST:

RESULTS:

Frac Length 1,000'

COMMENTS:

106 MCF/Day (before)

HYDRAULIC FRAC TREATMENTS

COMPANY: Report by BJ Hughes (8/21/79)
AREA: Panola County, Texas
DEPTH: 9,353'
TEMPERATURE: 243°F
INTERVAL: 352'
PERMEABILITY:
GAS, OIL, OR OTHER: Gas

TYPE TREATMENT:

VOLUME OF TREATMENT: 210,000 gal
RATE: 35 BPM
TYPE OF FLUID: Krystal 50
TYPE OF PROPPANT: 20-40 Ottawa Sand
AMOUNT OF PROPPANT: 600,000 lbs
AVG (lb/gal)
SLUGS ? (Y or N)
HIGHEST (lb/gal)

PRE FRAC TESTING (Y or N):

TYPE OF TEST:

POST FRAC TESTING (Y or N):

TYPE OF TEST:

RESULTS:

Frac Length 900'

COMMENTS:

- . New Well
- . 3,800 MCF/Day

HYDRAULIC FRAC TREATMENTS

COMPANY: Report by BJ Hughes 8/21/79
AREA: Harrison County, Texas
DEPTH: 10,034 - 10,174'
TEMPERATURE: 256°F
INTERVAL: 200'
PERMEABILITY:
GAS, OIL, OR OTHER: Gas

TYPE TREATMENT: . 20,000 gal Super Krystal 60 + Diesel
VOLUME OF TREATMENT: . 45,000 gal Krystal 50 + Diesel
RATE: 12 BPM
TYPE OF FLUID:
TYPE OF PROPPANT: 20-40 Ottawa Sand
AMOUNT OF PROPPANT: 219,400 lbs
AVG (lb/gal)
SLUGS ? (Y or N)
HIGHEST (lb/gal)

PRE FRAC TESTING (Y or N):
TYPE OF TEST:

POST FRAC TESTING (Y or N):
TYPE OF TEST:

RESULTS:
Frac Length - 500'

COMMENTS:
135 MCF/Day (after)

HYDRAULIC FRAC TREATMENTS

COMPANY: Report by BJ Hughes 8/21/79
AREA: Freestone County, Texas (Cotton Valley Sand)
DEPTH: 11,582 - 11,720'
TEMPERATURE: 273°F
INTERVAL: 60'
PERMEABILITY:
GAS, OIL, OR OTHER:

TYPE TREATMENT:

VOLUME OF TREATMENT: 150,000 gal
RATE: 18 BPM
TYPE OF FLUID: Super Krystal 60 + Diesel
TYPE OF PROPPANT: 20=40 Ottawa Sand
AMOUNT OF PROPPANT: 300,000 lbs
AVG (lb/gal)
SLUGS ? (Y or N)
HIGHEST (lb/gal)

PRE FRAC TESTING (Y or N):

TYPE OF TEST:

POST FRAC TESTING (Y or N):

TYPE OF TEST:

RESULTS:

Grac Length 1,200'

COMMENTS:

2,500 MCF/Day (after)

HYDRAULIC FRAC TREATMENTS

COMPANY: Report by BJ Hughes 8/21/79
AREA: Upshur County, Texas
DEPTH: 11,790 - 11,828'
TEMPERATURE: 290°F
INTERVAL: 17'
PERMEABILITY:
GAS, OIL, OR OTHER:

TYPE TREATMENT: . 20,000 gals Krystal 50
VOLUME OF TREATMENT: . 2% Sta-Live Acid
RATE: 10 BPM
TYPE OF FLUID:
TYPE OF PROPPANT: 20-40 Ottawa Sand
AMOUNT OF PROPPANT: 5,000 lbs
AVG (lb/gal)
SLUGS ? (Y or N)
HIGHEST (lb/gal)

PRE FRAC TESTING (Y or N):
TYPE OF TEST:

POST FRAC TESTING (Y or N):
TYPE OF TEST:

RESULTS:

COMMENTS:

HYDRAULIC FRAC TREATMENTS

COMPANY: Cardinal Chemical
AREA: Elk City, Oklahoma
DEPTH: 14 to 16,000 ft.
TEMPERATURE: 280°F
INTERVAL: Deep Morrow 100 + ft.
PERMEABILITY: 0.2 md
GAS, OIL, OR OTHER: Gas

TYPE TREATMENT: Small and Large Sand Polymer Water Frac
VOLUME OF TREATMENT: Med
RATE: 10-15 BPM
TYPE OF FLUID: Gelled Water
TYPE OF PROPPANT: Small (100 mesh) and 20/40 SAnd, and Super Sand tail in (20/40)
AMOUNT OF PROPPANT:
 AVG (lb/gal) 1 to 2 lb/gal
 SLUGS ? (Y or N) No.
 HIGHEST (lb/gal) 4 lb/gal

PRE FRAC TESTING (Y or N):

TYPE OF TEST: No

POST FRAC TESTING (Y or N):

TYPE OF TEST: No

RESULTS:

COMMENTS:

HYDRAULIC FRAC TREATMENTS

COMPANY: Cardinal Chemical
AREA: West Texas
DEPTH: 22,000 ft
TEMPERATURE: 325°F
INTERVAL: ~ 100 - 200 ft.
PERMEABILITY: 0.1 md
GAS, OIL, OR OTHER: Gas

TYPE TREATMENT: Deep Acid Frac
VOLUME OF TREATMENT: Med
RATE: 10-15 BPM
TYPE OF FLUID: HCC
TYPE OF PROPPANT: None
AMOUNT OF PROPPANT:
 AVG (lb/gal) 0.0
 SLUGS ? (Y or N)
 HIGHEST (lb/gal)

PRE FRAC TESTING (Y or N):
TYPE OF TEST: N/A

POST FRAC TESTING (Y or N):
TYPE OF TEST: N/A

RESULTS:

COMMENTS:

HYDRAULIC FRAC TREATMENTS

COMPANY: Coastal States Gas
AREA: Anadarko Basin
DEPTH: 15,273 ft.
TEMPERATURE: 260°F
INTERVAL:
PERMEABILITY: Morrow Sandstone
GAS, OIL, OR OTHER:

TYPE TREATMENT:
VOLUME OF TREATMENT: 60,000 gal.
RATE: 13 BPM (9,500 psi pump pressure)
TYPE OF FLUID: geled kerosene
TYPE OF PROPPANT: 20-40 sand
AMOUNT OF PROPPANT: 56,000 lbs.
AVG (lb/gal)
SLUGS ? (Y or N)
HIGHEST (lb/gal)

PRE FRAC TESTING (Y or N):
TYPE OF TEST:

POST FRAC TESTING (Y or N):
TYPE OF TEST:

RESULTS:
Significant improvement.

COMMENTS:
- Treatment corrected skin damage problems.

HYDRAULIC FRAC TREATMENTS

COMPANY: Conoco
AREA: Ellenburger (West Texas)
DEPTH: 20,000 ft
TEMPERATURE: 350° - 400°F
INTERVAL :
PERMEABILITY:
GAS, OIL, OR OTHER:

TYPE TREATMENT: Acid Frac
VOLUME OF TREATMENT: 40,000 gal
RATE:
TYPE OF FLUID: Acid
TYPE OF PROPPANT: None
AMOUNT OF PROPPANT:
 AVG (lb/gal)
 SLUGS ? (Y or N)
 HIGHEST (lb/gal)

PRE FRAC TESTING (Y or N):
TYPE OF TEST:

POST FRAC TESTING (Y or N):
TYPE OF TEST:

RESULTS:

COMMENTS:

* Limestone Formation

HYDRAULIC FRAC TREATMENTS

COMPANY: Conoco
AREA: Corpus Christi (Webb County)
DEPTH:
TEMPERATURE: 250°F (highest)
INTERVAL:
PERMEABILITY:
GAS, OIL, OR OTHER:

TYPE TREATMENT:
VOLUME OF TREATMENT:
RATE:
TYPE OF FLUID: Cross Link Gel (poly sacharide derivative)
TYPE OF PROPPANT: 20 - 40 mesh
AMOUNT OF PROPPANT:
 AVG (lb/gal) 4 lb/gal
 SLUGS ? (Y or N)
 HIGHEST (lb/gal) 6 - 8 lb/gal

PRE FRAC TESTING (Y or N):
TYPE OF TEST:

POST FRAC TESTING (Y or N):
TYPE OF TEST:

RESULTS:

COMMENTS:

* Not doing too many frac jobs.

HYDRAULIC FRAC TREATMENTS

COMPANY: Dowell

AREA:

DEPTH:

TEMPERATURE: 400°F

INTERVAL:

PERMEABILITY:

GAS, OIL, OR OTHER:

TYPE TREATMENT:

VOLUME OF TREATMENT:

RATE:

TYPE OF FLUID: YF 400 Stratafrac

TYPE OF PROPPANT:

AMOUNT OF PROPPANT:

AVG (lb/gal)

SLUGS ? (Y or N)

HIGHEST (lb/gal)

PRE FRAC TESTING (Y or N):

TYPE OF TEST:

POST FRAC TESTING (Y or N):

TYPE OF TEST:

RESULTS:

COMMENTS:

- * Type of fluid depends on formation condition and permeability.
- * Water might be adequate in tight formation.
- * Mentioned earlier meeting with project team.

HYDRAULIC FRAC TREATMENTS

COMPANY: Exxon
AREA: E. Texas Division - Hainesville Lime, Cotton Valley Lime
DEPTH: 12,000 ft.
TEMPERATURE: 290°F
INTERVAL: 100 ft. gross pay
PERMEABILITY: 0.3 md
GAS, OIL, OR OTHER: Gas

TYPE TREATMENT: Versagel Polymer Water Planar Frac
VOLUME OF TREATMENT: 100,000 gal
RATE: 12 BPM
TYPE OF FLUID: Various Polymer/water solution (Versagel 14, 15 or Klean 160)
TYPE OF PROPPANT: Bauxite
AMOUNT OF PROPPANT:
 AVG (lb/gal) 1 to 3 lb/gal
 SLUGS ? (Y or N) No
 HIGHEST (lb/gal) 7 lb/gal

PRE FRAC TESTING (Y or N): Yes, Production Tests
TYPE OF TEST:

POST FRAC TESTING (Y or N): Yes, Production Tests & Temperature
TYPE OF TEST: Logging

RESULTS: Good results w/Hydraulic Fracturing, Acid Fracs would not work here.
Results are independent of the amount of bauxite used.

COMMENTS:

HYDRAULIC FRAC TREATMENTS

COMPANY: Forest Oil
AREA: McAllen Ranch, Y Field
DEPTH: 13,000 ft.
TEMPERATURE: 380 - 400°F (estimated from logging runs)
INTERVAL: 100 ft (min) to 400 ft (max) gross; 160 ft net
PERMEABILITY: .05 md
GAS, OIL, OR OTHER: Gas

TYPE TREATMENT:
VOLUME OF TREATMENT: 375,000 gal
RATE: ~ 12 BPM (11,000 psi pump pressure)
TYPE OF FLUID: Versi gel*
TYPE OF PROPPANT Bauxite*
AMOUNT OF PROPPANT:
 AVG (lb/gal)
 SLUGS ? (Y or N)
 HIGHEST (lb/gal)

PRE FRAC TESTING (Y or N):
TYPE OF TEST:

POST FRAC TESTING (Y or N):
TYPE OF TEST:

RESULTS: Very good results.

COMMENTS:

*Started with Halliburton high gel and 20-40 Brady sand; later switched to versigel and bauxite.

HYDRAULIC FRAC TREATMENTS

COMPANY: Gulf Oil Company

AREA: South Texas

DEPTH: 12,000 ft.

TEMPERATURE: 300°F

INTERVAL:

PERMEABILITY:

GAS, OIL, OR OTHER:

TYPE TREATMENT:

VOLUME OF TREATMENT:

RATE:

TYPE OF FLUID: Stand high-temperature fluid supplied by service companies

TYPE OF PROPPANT: Sand (20-40)

AMOUNT OF PROPPANT:

AVG (lb/gal)

SLUGS ? (Y or N)

HIGHEST (lb/gal)

PRE FRAC TESTING (Y or N):

TYPE OF TEST:

POST FRAC TESTING (Y or N):

TYPE OF TEST:

RESULTS:

- Length of fracture about 600 ft.

COMMENTS:

HYDRAULIC FRAC TREATMENTS

COMPANY: Houston Natural Gas

AREA: Harris Co. - Wilcox

DEPTH: 13,000 ft.

TEMPERATURE: 320°F

INTERVAL: 2.

PERMEABILITY: 0 to 2 md

GAS, OIL, OR OTHER: Gas

TYPE TREATMENT: Kiel Frac

VOLUME OF TREATMENT: 3,500 bbls (2,200 to 2,500 bbl into formation)

RATE: 11 to 12 BPM

TYPE OF FLUID: 12#/1000 gal - Guar + XC (5 to 1)

TYPE OF PROPPANT: 100 mesh sand

AMOUNT OF PROPPANT: 100,000 lb.

AVG (lb/gal) 8 #/gal slugs

SLUGS ? (Y or N) Yes

HIGHEST (lb/gal) + 12 lb/gal sand out at end

PRE FRAC TESTING (Y or N): Y

TYPE OF TEST: Build up Data 22 day shut in 3,835 psi BHP @ 22 days

POST FRAC TESTING (Y or N): Y

TYPE OF TEST: Prod. Test

RESULTS: 0 + 1 mmcf/d

158 mmcf/d + 1.6 mmcf/d

COMMENTS: Good Well, Cleanup very important

HYDRAULIC FRAC TREATMENTS

COMPANY: Miami Oil
AREA: Zapata Co., Tex-Wilcox
DEPTH: 11,500 ft.
TEMPERATURE: 350°F
INTERVAL: 100 ft.
PERMEABILITY: ~20 md
GAS, OIL, OR OTHER: Gas

TYPE TREATMENT: Kiel Frac (5 to 6 stages)
VOLUME OF TREATMENT: 2,500 BBLS
RATE: 11 to 13 BPM
TYPE OF FLUID: 12#/1,000 gal Guar + XC (5 to 1)
TYPE OF PROPPANT: 100 mesh sand
AMOUNT OF PROPPANT: 100,000 lbs.
AVG (lb/gal)
SLUGS ? (Y or N) Yes!
HIGHEST (lb/gal) 8#/gal

PRE FRAC TESTING (Y or N): N
TYPE OF TEST: Wildcat Well

POST FRAC TESTING (Y or N): y
TYPE OF TEST: Long-Term Production Test

RESULTS: 1 mmcf/d Gas Well

COMMENTS: Clean up very important because of high pressure.

HYDRAULIC FRAC TREATMENTS

COMPANY: Monsanto
AREA: Madden, Wyoming - Mesa Verde
DEPTH: 16,000 feet
TEMPERATURE: 310°F
INTERVAL: 100 to 500 ft
PERMEABILITY: Low
GAS, OIL, OR OTHER: Gas

TYPE TREATMENT:
VOLUME OF TREATMENT:
RATE:
TYPE OF FLUID: POTENTIAL WELLS
TYPE OF PROPPANT: NOT YET FRACED.
AMOUNT OF PROPPANT:
 AVG (lb/gal)
 SLUGS ? (Y or N)
 HIGHEST (lb/gal)

PRE FRAC TESTING (Y or N):
TYPE OF TEST:

POST FRAC TESTING (Y or N):
TYPE OF TEST:

RESULTS:

COMMENTS:

HYDRAULIC FRAC TREATMENTS

COMPANY: Shell FRAC GRADIENT: 1.0 psi/ft
AREA: S. Texas SURFACE PRESSURE: 12,000 - 14,000 psi
DEPTH: 12 to 13,000 ft
TEMPERATURE: 300 to 320°F
INTERVAL: Gross 300 - 400 ft, Net 100 ft.
PERMEABILITY: 0.2 md
GAS, OIL, OR OTHER: Gas

TYPE TREATMENT: 20% prepad KCL, 30-35% pad, staggered gel concentration
 16-100 Versagel
VOLUME OF TREATMENT: 130,000 gal
RATE: 12-15 BPM
TYPE OF FLUID: Versagel
TYPE OF PROPPANT: Sand 250,000 lb 20/40 ottawa
AMOUNT OF PROPPANT:
 AVG (lb/gal)
 SLUGS ? (Y or N)
 HIGHEST (lb/gal) 5 to 6

PRE FRAC TESTING (Y or N):
TYPE OF TEST: Buildup Test

POST FRAC TESTING (Y or N):
TYPE OF TEST: Temp Logs

RESULTS:

COMMENTS:

HYDRAULIC FRAC TREATMENTS

COMPANY: Southport Exploration
AREA: Roger Hill County (West Oklahoma)
DEPTH: 14,000 ft.
TEMPERATURE: 250°F
INTERVAL: 40 ft (Total 80 ft)
PERMEABILITY:
GAS, OIL, OR OTHER: Gas

TYPE TREATMENT:

VOLUME OF TREATMENT: 2,400 Barrels
RATE: 10 BPM (1300 psi pump pressure)
TYPE OF FLUID: Western (Polaris Gel)
TYPE OF PROPPANT: Super Sand
AMOUNT OF PROPPANT: 120,000 lbs.
AVG (lb/gal)
SLUGS ? (Y or N)
HIGHEST (lb/gal)

PRE FRAC TESTING (Y or N):

TYPE OF TEST:

POST FRAC TESTING (Y or N):

TYPE OF TEST:

RESULTS: .5 MCFD (before)
3 MCFD (after)

COMMENTS:

- Super Sand worked okay.
- Two stage job; total interval was 80 ft.

HYDRAULIC FRAC TREATMENTS

COMPANY: Western Co.
AREA: Ellenberger Formation - West Texas
DEPTH: 20,000+ ft.
TEMPERATURE: 405°F
INTERVAL: 200+ ft.
PERMEABILITY: 0.01 md
GAS, OIL, OR OTHER: Gas

TYPE TREATMENT: Frac Job
VOLUME OF TREATMENT: Medium Size
RATE: 10 to 15 BPM
TYPE OF FLUID: Gelled Water
TYPE OF PROPPANT: None
AMOUNT OF PROPPANT:
 AVG (lb/gal) 0.0
 SLUGS ? (Y or N)
 HIGHEST (lb/gal)

PRE FRAC TESTING (Y or N):
TYPE OF TEST: N/A

POST FRAC TESTING (Y or N):
TYPE OF TEST: N/A

RESULTS:

COMMENTS:

6.3 APPENDIX C

LIST OF COMPANIES and CONTACTS

AMOCO	Ralph Veatch
APACHE	Doug Stortz
ARCO	Glenn Martin
B. J. HUGHES	Rudy Novotny Charles Clark
CAMERON ASSOCIATES	Paul Cameron
CITGO	Larry Brown
COASTAL STATES GAS	Miles Reynolds
CONOCO	Harry McLeod Mike Till
COTTON PETROLEUM	Phil Keely
DOWELL	Max Stout
DRESSER TITAN	Robert McDaniel Babu Iyer
EXXON	John Gidley Tom Muecke Tom Matthews Rex Tillerson
FOREST OIL	Bob Tucker
GETTY	Ken Outwater Jr.
GULF	Bruce McGlothlin
HALLIBURTON	Ali Daneshy Al Jennings John Burnham John Dees

INTERCOMP	John Dempsey Walter Dowdle
KIEL ASSOCIATES	Othar Kiel
MAY PETROLEUM	Richard Schroeder
MITCHELL ENERGY	Harry Kozik
MONSANTO	John Rushing Bill Soderman
MOBIL	Lewis Medlin
PHOENIX RESOURCES	Jim Kishbaugh
PHILLIPS	Earl Hoff
SEI-AM	Steve Holditch
SHELL	Bill Fontenot Steve Weeks Rick Pearce
SMITH ENERGY	Dave Holcomb
SOHIO	Hugh Liming
SOUTHPORT EXP.	Dave Morrill
SUN OIL	Bill Hill
SUPERIOR OIL	Johnny Kopecky
TENNECO	Robert Campbell

TEXAS INT'L PETROLEUM

Terry Felter

TEXAS OIL & GAS

Jack Huppler

WESTERN CO.

Julius Carver
Larry Harrington
Bob Hannah