CFSU 42-7
Cove Fort, Sulphurdale Unit
Initial Flow Test

Union Oil Company of California
Geothermal Division
Santa Rosa, California

Brian Maassen
July 24, 1978

SUMMARY OF CFSU 42-7 PIT TEST

PRODUCTION TEST

Date	5/16/78
Start Nitrogen Injection	15:45
Stop Nitrogen Injection	22:45
End Flow Period	7:25 7/17/78
Maximum Rate	47,000 lb/hr
Wellhead Pressure	3 psig
Maximum Bottom Hole Temperature	336°F @ 6900'
Total Fluid Produced	1,800,000 lbs

INJECTION TEST

Date	5/17/78
Injection Rate	53,000 lb/hr
Injection Temperature	70°F
Injection Wellhead Pressure	vacuum
Final Wellhead Pressure	0 psig
KH	$\pm$23,000 MDFT

CONCLUSIONS

1. The well will produce at a rate of 47,000 lb/hr at a wellhead pressure of 3 psig.

   The well dies immediately after shutin.

2. The reservoir temperature in the vicinity of the wellbore is $\pm$330°F. This corresponds to a flash of 0% at 100 psig and 4.22% flash at 50 psig.

3. The permeability of the formation is in the order of 23,000 md-ft.

4. The well should make an excellent injector because the pressure at 5000 ft is 688 psi below the normal hydrostatic gradient of 0.433 psi/ft. Calculations assuming the above permeability and steady-state radial flow indicate the well could take injection rates on the order of 1,000,000 lb/hr before fluid reaches the surface.

INTRODUCTION

A combination production and injection test was performed on CFSU 42-7 in Beaver County, Utah during the week of May 15, 1978. The test was designed to obtain temperature, chemical, production, injection, and permeability data. The results of the test are discussed in the following report.

BACKGROUND

The CFSU 42-7 was completed on March 14, 1978 with 7" tie-back from the surface to 3084' and 7" liner from 3084' to 7610'. The slotted liner sections are located between 4320' and 7520' The last temperature survey prior to the flow test was made on April 5, 1978 and indicated a maximum temperature of 325°F at 6050'. A bridge was encountered at 6064' during the survey. Temperatures of 344°F were measured at 7327' during production logging prior to completion of the well. The free standing fluid level during drilling operations was 1310'.

OPERATIONS

STATIC SURVEY

A static continuous temperature and differential survey was run on 5/15/78 prior to the flow test. The survey indicated a maximum temperature of 328°F at 6040' where a bridge was encountered. The 2500 foot isothermal zone from ±3600 to ±6100 found in surveys run prior to completion of the well was no longer present. A sensitive spinner tool was hung at several points in the zone and no flow was detected.

FLOW TO PIT

The test apparatus was set up as shown in Figure 1. It consists of a two-phase meter run, choke manifold and a flow spreader. The flow rates were calculated using the Murdock 2 phase correlation for orifice meters. The pit was also measured and a table of volume versus depth was prepared to use as a rough check against the metered rates. Flow rates could not be calculated during nitrogen injection because the Murdock correlation does not take the nitrogen into account.

Open ended coiled tubing was run into the well on 5/16/78 at ±50 ft/min, while circulating nitrogen at 1500 cubic feet per minute. An obstruction was encountered at 591 feet. When an attempt was made to back off 50 feet, the tubing parted and 591 feet was lost down hole. Coiled tubing was run into the well with a 3" washing

jet on the end to act as a guide shoe. The tubing was run at the same speed and nitrogen rate as above, past the bridge at 6040, until it tagged bottom at 7211'. Several attempts were made to get past 7211' but all were unsuccessful.

Fluid appeared at the surface several minutes after the tubing passed the free standing fluid level at 1310'. The well was lifted on nitrogen assist for 6 hours. Nitrogen rates were varied to see what effect it would have on production rates. The results indicated that the higher the nitrogen rate the higher the production rate. At times, the well produced a small amount of black, sandy grit. The nitrogen was shut off at 22:40 on 5/16/68. Flow continued unassisted at a rate of $\pm$48,000 lb/hr at 3 psig of wellhead pressure and decreased gradually over the next 9 hours to 43,000 lb/hr. The well was shut-in at 7:25 a.m. on 5/17/78. Shortly after shut-in, a 3" valve was opened on the wellhead, a noncondensible gas head was bled off and the wellhead pressure dropped to 0 psi. A total of 1,822,142 lbs was produced during the entire flow period.

CHEMICAL ANALYSIS

Several chemical samples were taken during the flow period and analyzed by Research. The complete analysis is shown in Table 1. The fluid had a total dissolved solids content of 3950 ppm. The silica geothermometer was analyzed and indicated a fluid temperature of 334°F. This is very close to the actual measured maximum temperature of 336°F. The Na, K, Ca geothermometer indicated a temperature of 436°F. This is unrealistic when

compared with temperature measured downhole.

POST FLOW SURVEY

Two hours after shut-in, a second continuous temperature and differential temperature survey was run, but the indicated temperatures were unrealistically high. A wireline temperature survey was run with Kuster tools as a check. The Kuster tool indicated a maximum temperature of 332°F at 6900'. The continuous survey was declared a misrun and a second temperature and differential temperature survey was run with a new tool. The results of this agreed with the Kuster run and a maximum temperature of 336°F was measured at 6900'.

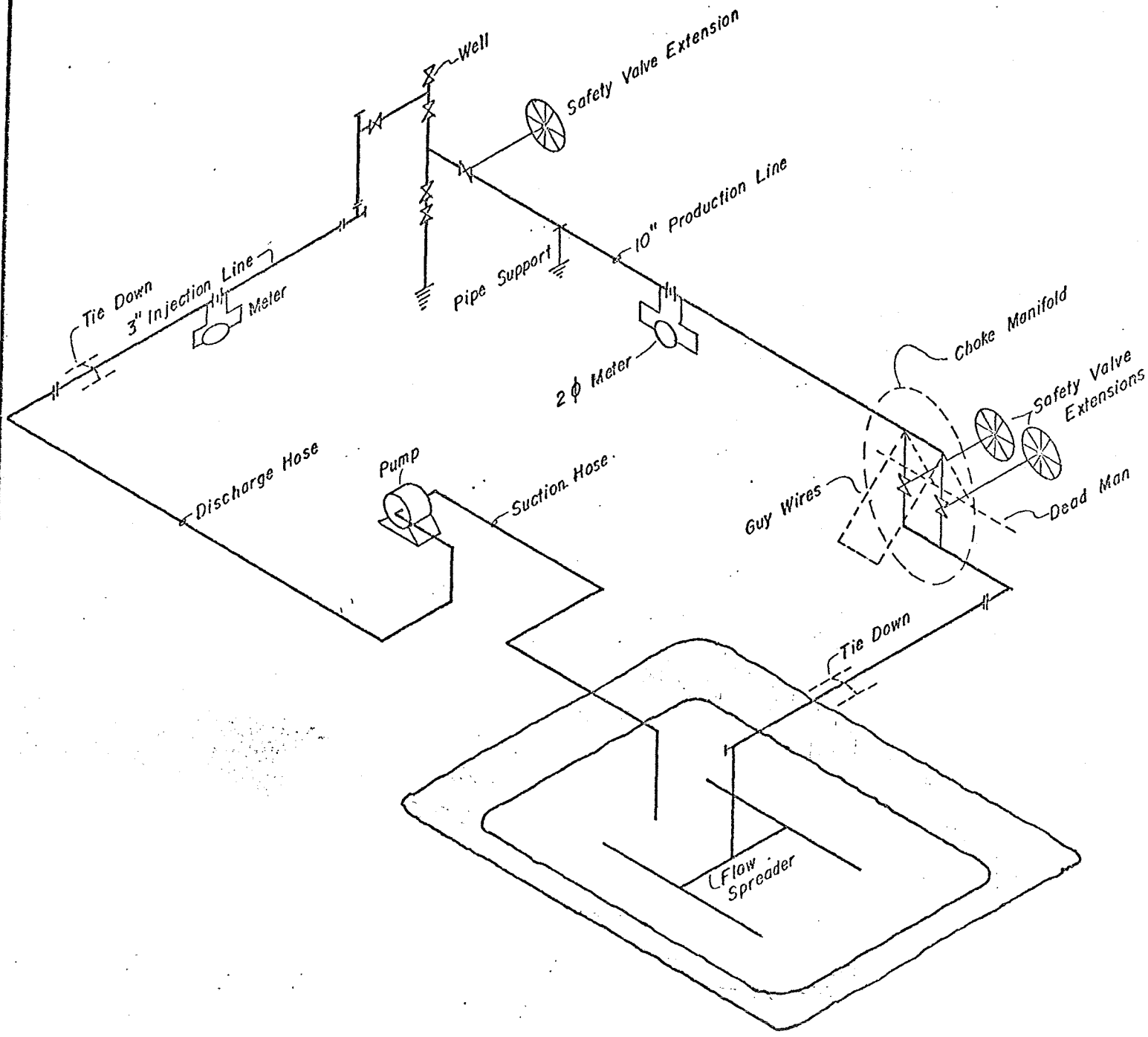
INJECTION PERIOD

The produced fluid was injected into the well for 17 hours on 5/17 and 5/18/78. The average injection rate was 53,000 lb/hr with the wellhead on a vacuum. Injection rates were limited by pump capacity. Flow rates were measured by the 3" meter run shown in Figure 1. A spinner survey was run but the results were inconclusive. The fluid level was found at 1370'.
A radioactive tracer survey showed fluid leaving the wellbore at the following locations:

Slotted Interval	Percent
4353'-4473'	51
4860'-4989'	3
5112'-5319'	20
5534'-5660'	13
below 5800'	13

No tracer shots were made below 5800' due to temperature limitations on the tool.

Data from flowing injection survey indicated a 29 psi pressure drop across the sandface at a flow rate of 50,000 lb/hr. A pressure falloff taken after shut-in indicated a permeability of 23,000 md-ft. It should be noted that the small pressure changes (29 psi) measured downhole are at the limits of the tools resolution; therefore, the accuracy of the permeability calculated here could be subject to a significant error. However, the very fact that the pressure drops were so small is an indication of high permeability. More accurate numbers could be obtained by injecting at higher rates in the region of 500,000 lb/hr.



REVISED	DATE

UNION OIL COMPANY OF CALIFORNIA - GEOTHERMAL DIVISION

C.F.S.U. 42-7
PIT TEST EQUIPMENT SCHEMATIC
FIGURE - 1

DRAWN	
FOR:	R.W.M.
BY:	L.D.C.
DATE:	6-30-78
SCALE:	None
DRAWING NUMBER	1377

ARS 78-289M

TABLE 1

Cove Fort Well (CFSU42-7) Compositional Analyses

5-16-78

Total Steam Production.

H_2S, ppm	97, 147	(2 separate samples)
NH_3, ppm	36, 78	(2 separate samples)

Separated Water. (pH=8.7)

Physical Properties

Specific Gravity	1.0028
Conductivity, μS/cm	5930
Suspended Solids, mg/l	392
Total Dissolved Solids, mg/l	3950

Elemental Analyses

Arsenic, mg/l	1.90
Boron, mg/l	7
Calcium, mg/l	43
Iron, mg/l	<.05
Magnesium, mg/l	6.0
Mercury, mg/l	nd<.0005
Potassium, mg/l	209
Silver, mg/l	<.02
Sodium, mg/l	1500

Anions

Bicarbonate, mg/l	101
Carbonate, mg/l	55
Chloride, mg/l	1590
Fluoride, mg/l	5.8
Nitrate, mg/l	0.03
Sulfate, mg/l	0.5
Sulfide, mg/l	3.5

Ammonia, mg/l 5.5

Silicon, mg/l 190, 200, 200 (3 separate samples)

Emission Spectrographic Analyses:

	TDS	Suspended Solids
Major, >10%	Na	Ca
Moderate, 1-10%	K	Fe, Si
Slight, 0.1-1%	Ca, Si	Al, Na
Trace, <0.1%	Al, Cu, Mg, Mo, Sr	Cu, Mg, Ma, Pb, Sr

APPENDIX

BWM

KH DETERMINATION FROM FALLOFF ON CFSU 42-7

DATE OF TEST 5/18/78

DETERMINE AVERAGE INJECTION RATE

RATE	HRS	Q
1	64,800	64,800
1.75	76,600	134,050
0.50	74,000	37,000
0.75	58,000	43 500
5.50	52,000	286 000
9.5		565, 350

AVERAGE RATE = 59000 LB/HR

FLOW TIME = 9.5 HRS

ΔT (MINUTES)	T+ΔT / ΔT	PRESS (PSIG)
0	—	1906
1	571	1904
2	286	1902
3	191	1900
4	143	1900
5	115	1900
10	58	1898
15	39	1898
60	10.5	1895
120	5.75	1894
180	4.17	1892
240	3.38	1890
300	2.90	1888
360	2.58	1888
420	2.36	1888
439	2.30	1888

FALLOFF ON CFSU 42-7 5/18/78 CONT

SLOPE = 7 PSI/∿

RATE = 59000 LB/HR

TEMP = 250° SPVOL = 0.017006 μ = 0.23

CONVERT RATE TO BBL/DAY

$$\frac{(59000)(0.017006)(24)}{5.615} = 4288. \text{ BPD}$$

$$kh = \frac{(162.6)(0.23)(4288)}{7} = \boxed{22900 \text{ MD FT}}$$

$$S = 1.151\left[\frac{P_{WF} - P_{1HR}}{m} - \text{Log}\left(\frac{kh}{\phi H \mu c r_w^2}\right) + 3.23\right]$$

P_{WF} = 1906 ϕH = 200 r_w^2 = 0.1329

P_{1HR} = 1891. μ = 0.23 m = 7

KH = 9960 $c = 12 \times 10^{-6}$

$$S = 1.151\left[\frac{1906 - 1891}{7} - \text{Log}\left(\frac{22900}{(200)(0.23)(12\times10^{-6})(.1329)}\right) + 3.23\right]$$

$S = -3.6$ $\Delta P_S = 0.87(m)(s) = 0.87(7)(-3.12) = -19$ PSI

$$EFF = \frac{P_{WF} - P_{WS} - \Delta P_S}{P_{WF} - P_{WS}} = \frac{1906 - 1880 - (-19)}{1906 - 1850} = 1.73$$

P_{WS} = 1880

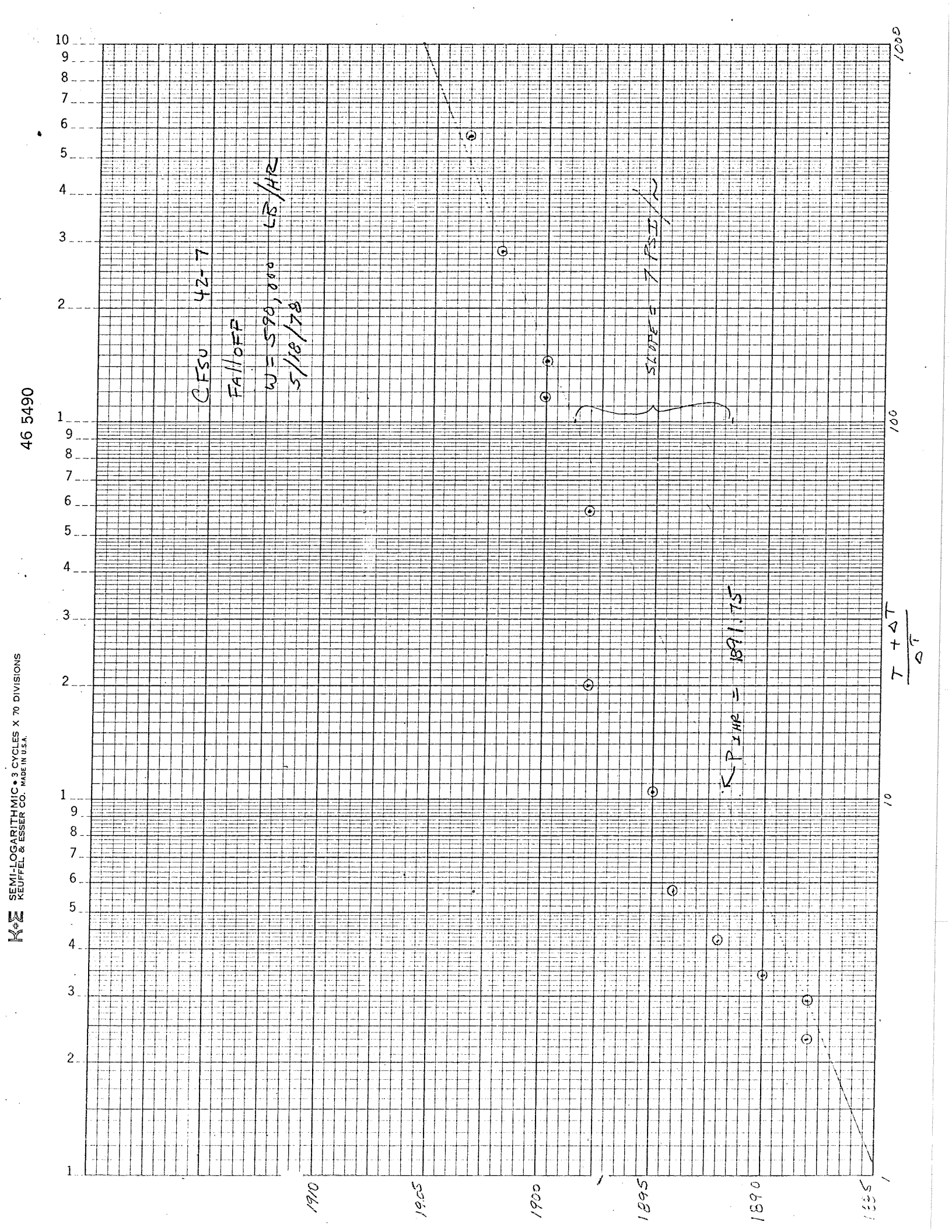
FALLOFF ON CFSU 42-7 5/18/78

CHECK STEADY STATE KH AGAINST BUILD UP

$$kh = \frac{603.86\ W(SPROL)(\mu)\ \ln(R_e/r_w)}{\Delta P\ E}$$

P_{WS} = 1877 FM 5/9/78
P_{WF} = 1906
ΔP = 1906 − 1877 = 29

$$kh = \frac{603.86(59000)(0.017006)(0.73)(7.06)}{29\ (1.75)} = \boxed{19600\ md\text{-}FT}$$


CFSU 42-7
FALLOFF
W=590,000 LB/HR
5/18/78
SLOPE = 7 PSI/∿
KP/HR = 891.75
T + ΔT / Δt
46 5490
SEMI-LOGARITHMIC • 3 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
1910
1905
1900
1895
1890
1885
1000
100
10
1

LOCATION LOG

AK

5 16 78 1 5

CPSU 43-7 PIT TEST

5/16 - N_2 INJECTION & FLOW TEST

Time	
0900	SAFETY MEETING
0913	BLEED-OFF PRESSURE
0915	OPEN VALVE
0920	ATTEMPT TO RUN TUBING INTO WELL
0935	PULL TUBING OUT & DISCONNECT BOPE TO INSTALL CENTRALIZER ON TUBING
	CONTINUOUS ATTEMPTS TO RUN TUBING UNSUCCESSFUL, APPARENTLY CATCHING ON 7" TIEBACK LAP AT WELLHEAD. RUN FREE STINGER OF TUBING PAST LIP, THEN CONNECT IT TO TUBING ON SPOOL.
1338	ATTEMPT TO RUN TUBING INTO HOLE, INJECTING N_2 @ 1200 CFM
1349	HIT OBSTRUCTION - DROPPED 591' of TUBING INTO HOLE
1518	USING SAME METHOD, START RUNNING TUBING INTO HOLE
1545	TUBING ENTERED FLUID LEVEL (APPROX 1300')
1550	FLUID TO SURFACE - FROTHY, WHITE FLUID
1600	2500' TUBING DEPTH - GRAY FLUID TO SURFACE
1620	FAINT SMELL OF H_2S PRESENT
1635	REACH 5000', HOLD AT 5000' TO VARY INJECTION RATE

PK 5 16782 5

CFSU 43-7 PIT TEST

TIME	
1640	INCREASE N_2 INJECTION RATE TO 1500 cfm
1655	BEGIN TO METER FLOW WITH BARTON #1 - NO BACK PRESSURE
1657	CONTINUE RUNNING INTO HOLE PAST 5000'
1705	BARTON #1 METER FAILED
1720	NO SIGN OF BRIDGE - TUBING DEPTH = 6900'
1723	BARTON #1 METER RUNNING AGAIN
	GRIT PRODUCED THROUGOUT TEST
1755	HIT OBSTRUCTION AT 7211', PULLED TO 7160' & HELD STILL INJECTING 1500 CFM PRODUCING MILKY WHITE FLUID AGAIN ALSO PRODUCING LARGER AMOUNTS OF GRIT
1835	RUN SLOWLY INTO HOLE TO 7211', HIT OBSTRUCTION PULL BACK TO 7160' & HOLD
1840	CUT N_2 INJECTION RATE TO 500 cfm
1918	INCREASE N_2 INJECTION TO 750 cfm
2100	CUT N_2 INJECTION RATE TO 300 cfm
2130	START PULLING TUBING OUT OF HOLE
2240	SHUT OFF N_2, OUT OF HOLE
2250	OPEN INJECTION LINE TO BLEED-OFF WELL

Pk 5 16 78 3 5

CFSU 42-7 Pit Test

Time	
0357	Partially Close 10" Master Valve to Check for Tubing
0330	Close Injection Line, Begin to Meter Slight Flow
7/17/78	Due to Connectors on Tubing, unable to pull Nowsco Tubing Completely out of Wellhead.
0730	119°F 0 psi 5" H_2O
0735	Shut-In Well @ 0 psi
0737	~~Incident~~ P_{TS} = 5 psi
0738	P_{TS} = 7 psi
0730	P_{TS} = K psi
8:05	" = 13 psi
8:15	" = 15 psi
8:30	" = 19 psi
8:45	" = 25 psi
8:50	Opens 3" and blew off non condensibles 0 psi, well died
1025	Run Temp Survey - Reached fluid level @ 1870'
11:05	~~Tool~~ Temp Tool Failed at 1900'
1155	Run in Hole w/Temp [illegible]
1840	Tool Failed @ 6750' - 60°F
1450	Run Tool To [illegible] Using Different Panel
	Temperature = [illegible] 361.8°F
	6700' 372.5°F
	Run to Bottom of Hole @ [illegible] & Log Pulling out up [illegible]
	Tool Failed POH

PK 5 17 45

CFSU 12-7

1625 RUN KUSTER TEMP SURVEY
1 193 NO FLUID
2000' 306
3000' 306
4000' 321 FLUID LEVEL @ 670'
5000 327
6000 339
6910 338

1900 START INTO HOLE WITH GO TEMP SURVEY

1935 TOOL FAILED — POH

1955 TOOL REPAIRED, START IN HOLE AGAIN

2130 PICK UP DEPTH @ 6919' 336.9F
START POH
POSSIBLE TOP OF TUBING FISH @ 6500'

2230 BEGIN INJECTING WATER SLOWLY
INITIAL PIT LEVEL = 5'

2250 SHUT-DOWN PUMP DUE TO SAND PLUGGING VALVE

2310 RESTART PUMP @ 30SPM

5/18
0730 PUMP LOST PRIME

0800 PUMP RUNNING AGAIN

0825 PUMP DOWN

0855 PUMP RUNNING

5 18 78 5 5

0910	PUMP DOWN
0930	PUMP ON
0138	DOWN
1055	BACK ON
1130	START SPINNER SURVEY
1145	TOOL FAILED - POH
1200	RIH W/SPINNER SURVEY, TOOL FAILED - POH
1245	RIH W/SPINNER SURVEY
1520	COMPLETE TEMP SURVEY
1540	START RA SURVEY
1700	COMPLETE RA SURVEY
1830	START CLOCKS FOR FALL-OFF & GRADIENT SURVEY
1850	START IN HOLE W/ABOVE
2100	SHUT DOWN PUMPS & :. BEGIN FALL-OFF SURVEY

CFSU 42-7 PIT TEST PK PRODUCTION READINGS

5 16 78 - 4

ORIFICE SIZE: 7 1/2"
METER RUN: 12"

TIME START: 1518

P_{TS} @ TIME OF TEST 10 psi
$T_{INITIAL}$ = AMBIENT < 50°F

TIME	PRESSURE (PSIG)	WELLHEAD TEMP °F	$P_{UPSTREAM}$ (PSIG)	DIFFERENTIAL INCHES (H_2O)	PIT LEVEL/VOLUME/RATE	COMMENTS
INITIAL	10	< 50			2 1/2'/6387 ft³/—	
1550	22	125	BEGIN INTERMITTANT FLOW TO SURFACE			INJ N_2 @ 1200 cfm
1555	15	190				
1600	17	190				
1605	17	209				
1610	25	218				@3210'
1615	25	222				
1620	25/23 GAUGE	227				
1625	25	228	RATE NOT ACCURATE —>		3'/10285 ft³/735,401 lb/hr	@4400'
1630	25	226				
1635	25	225/228 GLASS				@5000'
1640	25	NOT SETTLED 22?/230 GLASS				N_2 @ 1500 cfm
1645	25	228				@5000'
1650	30	240				@5000'
1655	35	242	ATTEMPT TO USE FLOW METER - NO BACK PRESSURE			@5000'
1700	35	242	18+	17		
1705	35	244	18	METER FAILED		
1710	30	228				
1715	35	235				@6200'
1720	35	236				
1725	35	236	22	43		
1730	35	230/231 GLASS	20	42		

TIME	PRESSURE (PSIG)	WELLHEAD TEMP (°F)	PIPESTREAM (PSIG)	DIFFERENTIAL (INCHES H_2O)	PIT LEVEL/VOLUME/RATE	COMMENTS
1735	30	240/242 GLMT	25	52		1500 cfm @ 6700'
1740	30	240	18	41		
1745	30	236	20	40		
1750	35	241	19	45		" @ 7191'
1755	40	250	25	62		" @ 7211'
1800	35	240	23	45	3½'/15,776 ft³/215,000 lb/HR	" @ 7160'
1805	40	243	20	45		" "
1810	40	242	37	65		" "
1815	40	244	22	42		" "
1830	35	242	24	47		" "
1845	40	248	25	55		500 cfm @ 7160'
1900	35	238	19	44		" "
1915	30	230	15	35		" "
1930	33	238	18	43		750 cfm @ 7160'
1945	45	250	27	60		" "
1950	40	244	23	50	4'/21,267 ft³/186,900 lb/HR	" "
2000	40	245	23	52		" "

CFSU 43-7 PIT TEST

PRODUCTION REDRAWS

PK

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CFSU 42-7 PIT TEST

PK

PRODUCTION READINGS

5 16 78 3 4

TIME	PRESSURE (PSIG)	WELLHEAD TEMP (°F)	PUPSTREAM (PSIG)	DIFFERENTIAL (INCHES H_2O)	PIT LEVEL/VOLUME/RATE	COMMENTS
2015	35	243	22	48		75 SCFM @ 7160'
2030	36	245/250 GLASS	24	52		" "
2045	37/39 GAGE	245	24	52		" "
2100	37/39 GAUGE	244	22	51		300 SCFM @ 7160'
2115	36	237	20	43		" "
2130	32	230	17	35		START OUT OF HOLE CONTINUE N_2 @ 300 SCFM
2135	30	230	14	35		
2140	30	231	15	36		
2145	33	232	15	36½	4½'/28,428 FT³/239,900 LB/HR	
2150	30	229	14	34		
2155	30	230	14	36		
2200	40	243	20	44		
2205	40	241	20	50		
2210	35	235	16	45		
2215	35	237	17	45		
2220	33	232	15	40		
2225	27	227	14	36		
2230	25	223	12	31		
2240	SHUT-OFF N_2 INJECTION					
2245	14	208	6	16		
2250	2	205	4	15"	OPEN INJECTION LINE	

CFSU 42-7

PK

PRODUCTION READINGS

5 16 78 4 4

TIME	WELLHEAD PRESS (PSIG)	WELLHEAD TEMP (°F)	P UPSTREAM (PSIG)	DIFFERENTIAL (INCHES H_2O)	PIT LEVEL/VOLUME/RATE	COMMENTS
2255	3	200				
2300	3	195				
2305	4	205				
2310	4	205				
2315	4	205				
2320	4	205				
2325	3	205				
2330		205	3	11		
2345		203	3	11		
2400		203	3	11		
5/17						
0100		202	2	7½		
0200		199	2	7½		
0300		197	2	7		
0400		197	2	7		
0500		197	2	6½		
0600		200	2	6	5'/35,588 FT^3/54,150	
07[illegible]		19[illegible]	3	5½		

CFSU 42-7 INJECTION TEST

5 17 78 1 2

TIME	SPM	PURSTREAM	ΔP	P_{TF}	PIT LEVEL	COMMENTS
2230	30	—	12"	—	5' (MARKER 14)	
2235	40	—	16"	—		
2240	40	—	16"	—		
2245	40	—	16"	—		
2250	45	—	16"	—		
2255	45	—	0	—	SHUT DOWN DUE TO PLUGGING	
2310	30	—	9"	—		
2330	30	—	9"			
2335	35	—	12"	—	INCREASE PUMP RATE TO 35 SPM	
2400	35	—	12"	VAC		
5/18 0100	35	—	12"	VAC		
0200	34	—	11½"	VAC	4½' (MARKER 15)	
0300	34	—	11½"	VAC		
0400	34	—	11"	VAC		
0500	34	—	11"	VAC		
0600	34	—	10½"	VAC		
0700	34	—	10½"	VAC		

cc: Vane Suter
Steve Lipman
Del Pyle
Dick Dondanville
Don Ash
Olin Whitescarver
Frank Corbin ✓
Reservoir File

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CFSU - 42-7 INJECTION TEST

PK

TIME 5/18	SPM	P UPSTREAM	ΔP	P TF	PIT LEVEL	COMMENTS
[illegible]	34	—	10½"	1½ PSI		
	PUMP DOWN @ 0825, ON AGAIN @ 0855					
0900	34	–	7"	2½ PSI		
	PUMP DEAD @ 0910 ON AGAIN @ 0930					
0930	42	—	7"	0		
	PUMP DOWN @ 0938 ON AGAIN @ 1055					
1100	50	—	9"	3 PSI		
1115	50	—	20"	VAC		
1130	50	12 psi	19"	VAC		
1200	50	18 psi	20"	VAC		
1215	50	33	35	VAC		
1300	50	42	39	VAC	4' IN SUMP	
1330	50	44	33½	VAC		
1400	50	50	26	VAC		
1430	36	27	16	VAC	CUT BACK TO 36 SPM @ 1430	
1730	32	17½	12	VAC	3½' IN PIT	
2100	SHUT DOWN TO SURVEY FALL-OFF PRESSURES					