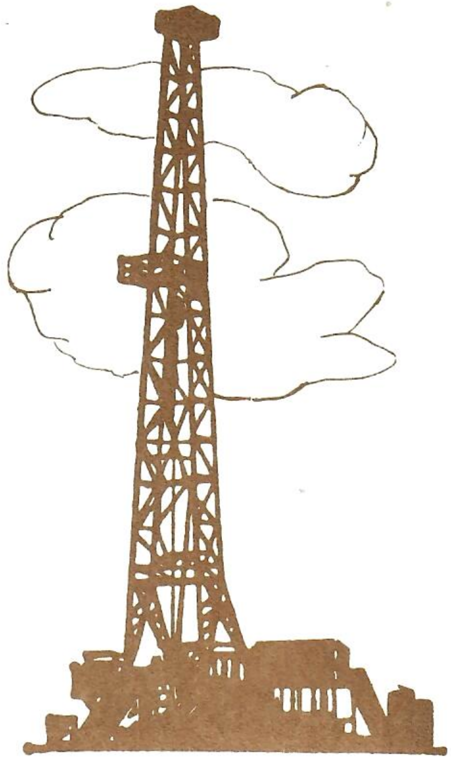


PICK TESTERS

Drill Stem Test Report

Box 341
Sterling, CO 80751

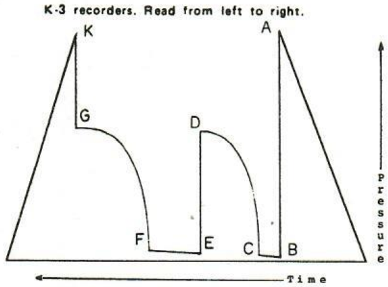
Phone
(970) 522-8387

GUIDE TO INTERPRETATION AND IDENTIFICATION OF DST CHARTS

In making any interpretation, our employees will give Customer the benefit of their best judgment as to the correct interpretation. Nevertheless, since all interpretations are opinions based on inferences from electrical, mechanical or other measurements, we cannot, and do not, guarantee the accuracy or correctness of any interpretations, and we shall not be liable or responsible, except in the case of gross or wilful negligence on our part, for any loss, costs, damages or expenses incurred or sustained by Customer resulting from any interpretation made by any of our agents or employees.

CODE USED ON CHART ENVELOPES

K-3 recorders. Read from left to right.



- A – Initial Hydrostatic
- B – First Initial Flow
- C – First Final Flow
- D – Initial Shut-in
- E – Second Initial Flow
- F – Second Final Flow
- G – Second Shut-in
- H – Third Initial Flow
- I – Third Final Flow
- J – Third Shut-in
- K – Final Hydrostatic

AK-1 recorders. Read from right to left.

NOMENCLATURE

Symbol	Definition	DST Unit
k	— permeability	millidarcys (md)
h	— pay thickness	feet (ft.)
u	— viscosity	centipoise
T	— reservoir temperature	^{o}Rankin (^{o}R)
Z	— gas compressibility factor at average condition	——
q_{sc}	— gas production rate	MCF/d
M	— Horner slope for liquid analysis	PSI/Cycle
Mg	— Horner slope for (P^2) gas analysis	PSI ^{2}/Cycle
Pi	— initial static reservoir pressure	PSI
Pwf	— flowing bottom hole pressure	PSI
ϕ	— porosity	(fraction)
rw	— well bore radius	ft.
S	— skin factor	——
AOF	— absolute open flow	MCF/d
D. R.	— damage ratio	——
re	— external drainage radius	ft.
ISIP	— initial shut-in pressure	PSI
FSIP	— final shut-in pressure	PSI
b	— approx. radius of investigation	ft.
t	— flowing time	hrs.
B	— formation volume factor	——
q	— liquid production rate	bbls/day
$\bar{c}$	— gas compressibility	1/PSI
c	— liquid compressibility	1/PSI

Build-Up Analysis Equations

Pressure Analysis

$$kh = \frac{162.6\ Q\mu\beta}{M}$$

$$S = 1.151\left[\frac{P_{1hr}-P_{wf}}{M} - \log\frac{k}{\phi\mu c_t r_w^2} + 3.23\right]$$

$$\Delta P_{Skin} = \frac{141.2\ Q\mu\beta\ S}{kh}$$

$$L = \sqrt{\frac{0.000148\ k\ \Delta t_x}{\phi\mu C_t}}$$

$$\text{Efficiency} = \frac{P - P_{wf} - \Delta P_{Skin}}{P - P_{wf}}$$

Pseudo–Pressure Analysis

$$kh = \frac{1.632 \times 10^3\ Q_g\ T}{M}$$

$$S = 1.151\left[\frac{\psi_{1hr}-\psi_{wf}}{M} - \log\left(\frac{k}{\phi\mu c_t r_w^2}\right) + 3.23\right]$$

$$\Delta\psi_{Skin} = \frac{1422\ Q_g\ T\ S}{kh}$$

$$L = \sqrt{\frac{0.000148\ k\ \Delta t_x}{\phi\mu C_t}}$$

$$\text{Efficiency} = \frac{P - P_{wf} - \Delta P_{Skin}}{P - P_{wf}}$$

Type Curve P Method

$$kh = 141.2\ Q\mu\beta\ \frac{P_{WD}}{\Delta P}$$

$$S = \frac{1}{2}\ \ln\left[\frac{C_D e^{2s}}{\frac{2.637\times10^{-4}\ k\Delta t}{\phi\mu C_t r_w^2\ t_D/C_D}}\right]$$

$$\Delta P_{Skin} = \frac{141.2\ Q\mu\beta\ S}{kh}$$

$$\text{Efficiency} = \frac{P - P_{wf} - \Delta P_{Skin}}{P - P_{wf}}$$

Type Curve P Method

$$kh = 141.2\ Q\mu\beta\ \frac{P_{WD}}{\Delta t\Delta P}$$

$$S = \frac{1}{2}\ \ln\left[\frac{C_D e^{2s}}{\frac{2.637\times10^{-4}\ k\Delta t}{\phi\mu C_t r_w^2\ t_D/C_D}}\right]$$

$$\Delta P_{Skin} = \frac{141.2\ Q\mu\beta\ S}{kh}$$

$$\text{Efficiency} = \frac{P - P_{wf} - \Delta P_{Skin}}{P - P_{wf}}$$

Fall-Off Analysis Equations

Semi–Log Analysis

Eq. (3.9) $$kh = \frac{162.6\ Q\mu\beta}{M}$$

$$S = 1.151\left[\frac{P_{inj}-P_{1hr}}{M} - \log\left(\frac{k}{\phi\mu c_t r_w^2}\right) + 3.23\right]$$

Eq. (3.10)

Log–Log Analysis

* Eq. (4.4) $$kh = 141.2\ Q\mu\beta\ \frac{P_{WD}}{\Delta P}$$

$$S = \frac{1}{2}\ \ln\left[\frac{C_D e^{2s}}{\frac{2.637\times10^{-4}\ k\Delta t_m}{\phi\mu C_t r_w^2\ t_D/C_D}}\right]$$

Pressure drop due to skin

Eq. (2.9) $$\Delta P_{Skin} = \frac{141.2\ Q\mu\beta\ S}{kh}$$

Flow Efficiency

Eq. (2.12) $$FE = \frac{P - P_{wf} - \Delta P_{Skin}}{P - P_{wf}}$$

investigation radius

Eq. (2.41) $$= 0.029\sqrt{\frac{k\,\Delta t}{\phi\mu C_t}}$$

Skin due to Partial Perforations

* Eq. (2.20) $$S_p = \left(\frac{h_t}{h_p} - 1\right)\left[\ln\left(\frac{h_t}{h_p}\sqrt{\frac{k_H}{k_V}}\right) - 2\right]$$

Advances in Well Test Analysis
Robert C. Earlougher Jr.
Monograph Volume 5 of the Henry L. Doherty Series

* Well Testing
John Lee
SPE Textbook Series Vol 1

Original pressure charts on file at the above location.

Phone (303) 522-8387

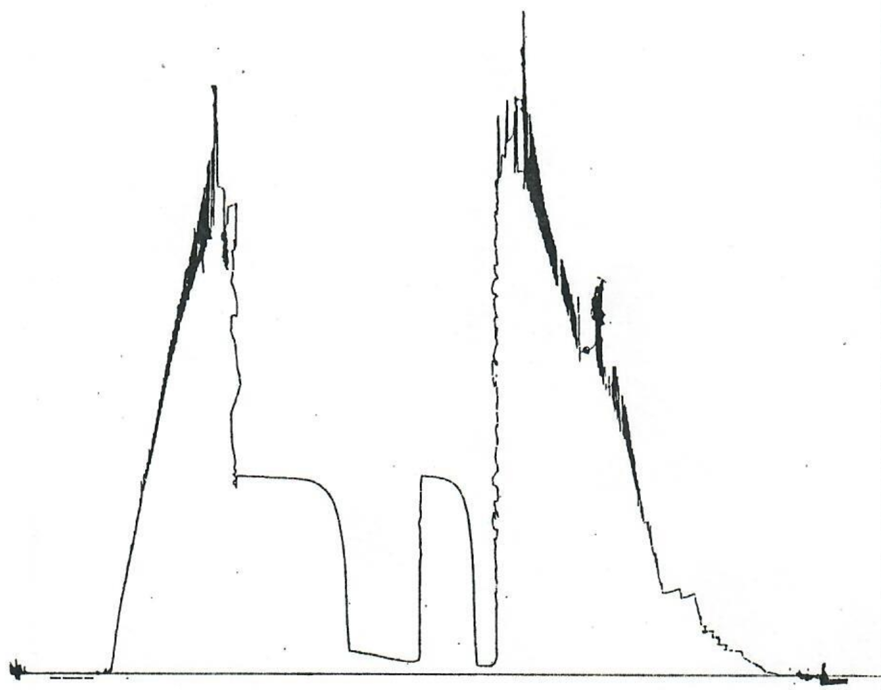
PICK TESTERS

Box 341
Sterling, CO 80751

Contractor	Ashby Drilling
Rig No.	2
Spot	SE/NE
Sec	22
Twp.	3 S
Rng.	58 W
Field	Roman Nose North
County	Adams
State	Colorado
Elevation	4975' KB
Formation	J-2 Sand

Surface Choke	1"
Bottom Choke	3/4"
Hole Size	7 7/8"
Core Hole Size	--
DP Size & Wt.	4 1/2" 16.60
Wt. Pipe	--
I.D. of DC	2 1/4"
Length of DC	523'
Total Depth	5882'
Type Test	Straddle
Interval	5768'- 5776'

Mud Type	Polymer/Gel
Weight	9.1
Viscosity	65
Water Loss	
Filter Cake	
Resistivity	3.0 @ 60 °F
	2,112 Ppm. NaCi
B.H.T.	160 °F
Co. Rep.	Chris Gough
Tester	David Pickering



		REPORTED	CORRECTED	
Opened Tool @		21:23		hrs.
Flow No.	1	15	16	min.
Shut-in No.	1	45	45	min.
Flow No	2	60	60	min.
Shut-in No.	2	90	92	min.
Flow No.	3			min.
Shut-in No.	3			min.

Recorder Type	Kuster AK-1
No.	13338
Cap.	4950 psi
Depth	5755 feet
Inside	X
Outside	
Clock Range	12 hrs.

Initial Hydrostatic	A	2897
Final Hydrostatic	K	2533
Initial Flow	B	124
Final Initial Flow	C	65
Initial Shut-in	D	1096
Second Initial Flow	E	114
Second Final Flow	F	149
Second Shut-in	G	1093
Third Initial Flow	H	
Third Final Flow	I	
Third Shut-in	J	

COMPANY	WESTERN OPERATING CO.
LEASE NAME & NO.	MADDERN #1-1
INTERVAL TESTED	5768'- 5776'
COUNTY	ADAMS
STATE	COLORADO
FORMATION	J-2 SAND
DATE	01-13-1997
TICKET #	1561
TEST #	1

Pipe Recovery 241' Mud cut water = 1.18 bbl.

Resistivity:

Top: 4.0 @ 58 Deg F/1.55 @ Res Temp/1,611 ppm NaCl., 980 ppm Cl.

Middle: 3.8 @ 58 Deg F/1.48 @ Res Temp/1,701 ppm NaCl., 1,034 ppm Cl.

Bottom: 3.8 @ 58 Deg F/1.48 @ Res Temp/1,701 ppm NaCl., 1,034 ppm Cl.

1st Flow: Tool opened with no blow and remained thru flow period.

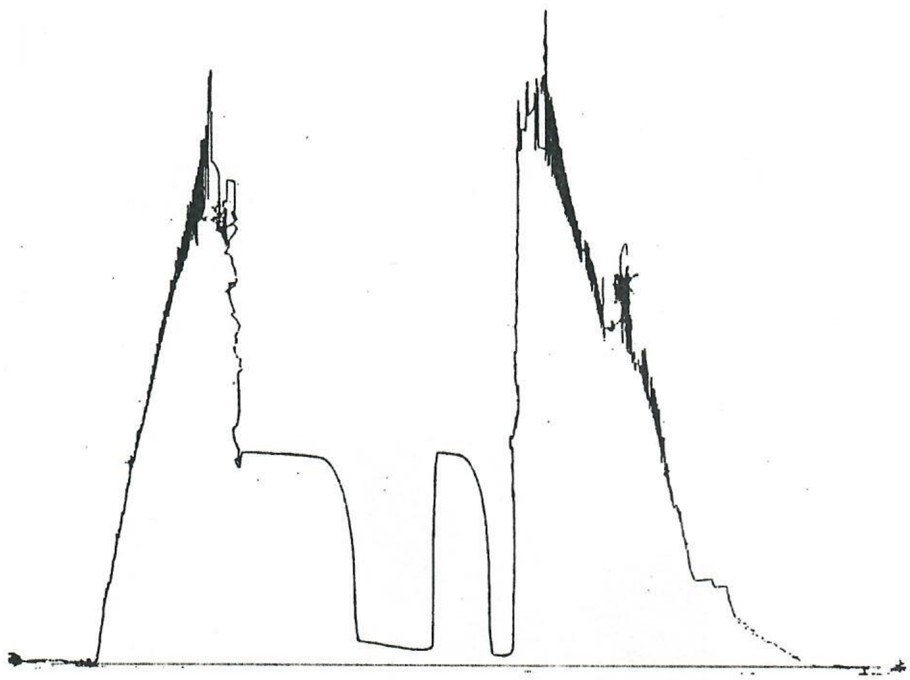
2nd Flow: Tool opened with no blow and remained dead throughout test.

Western Operating Co.

Maddern #1-1

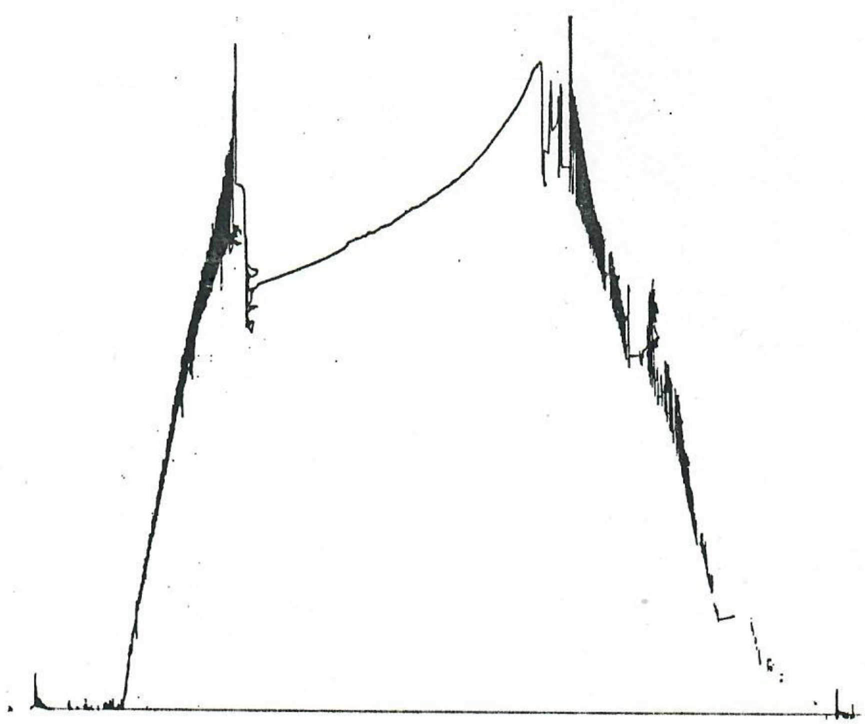
DST #1

01-13-1997



Recorder Type	Kuster AK-1		
No. 13617	Cap. 4550	psi	
Depth	5750	feet	
Inside X	Clock		
Outside	Range 12	hrs.	

Initial Hydrostatic	A	2887
Final Hydrostatic	K	2521
Initial Flow	B	83
Final Initial Flow	C	55
Initial Shut-In	D	1092
Second Initial Flow	E	99
Second Final Flow	F	124
Second Shut-In	G	1086
Third Inital Flow	H	
Third Final Flow	I	
Third Shut-In	J	



Recorder Type	Kuster AK-1		
No. 6249	Cap. 4950	psi	
Depth	5783	feet	
Inside	Clock		
Outside X	Range 12	hrs.	

Initial Hydrostatic	A	
Final Hydrostatic	K	
Initial Flow	B	
Final Initial Flow	C	
Initial Shut-In	D	
Second Initial Flow	E	
Second Final Flow	F	
Second Shut-In	G	
Third Inital Flow	H	
Third Final Flow	I	
Third Shut-In	J	

Bled to: 2136

Western Operating Co.
Maddern #1-1
DST #1

01-13-1997

SAMPLER REPORT

Pressure in Sampler:	100	psig
Total Volume of Sampler:	2150	cc.
Total Volume of Sample:	2100	cc.
Oil:	0	cc.
Water:	2100	cc.
Mud:	0	cc.
Gas:	0	cu. ft.
Other:	0	

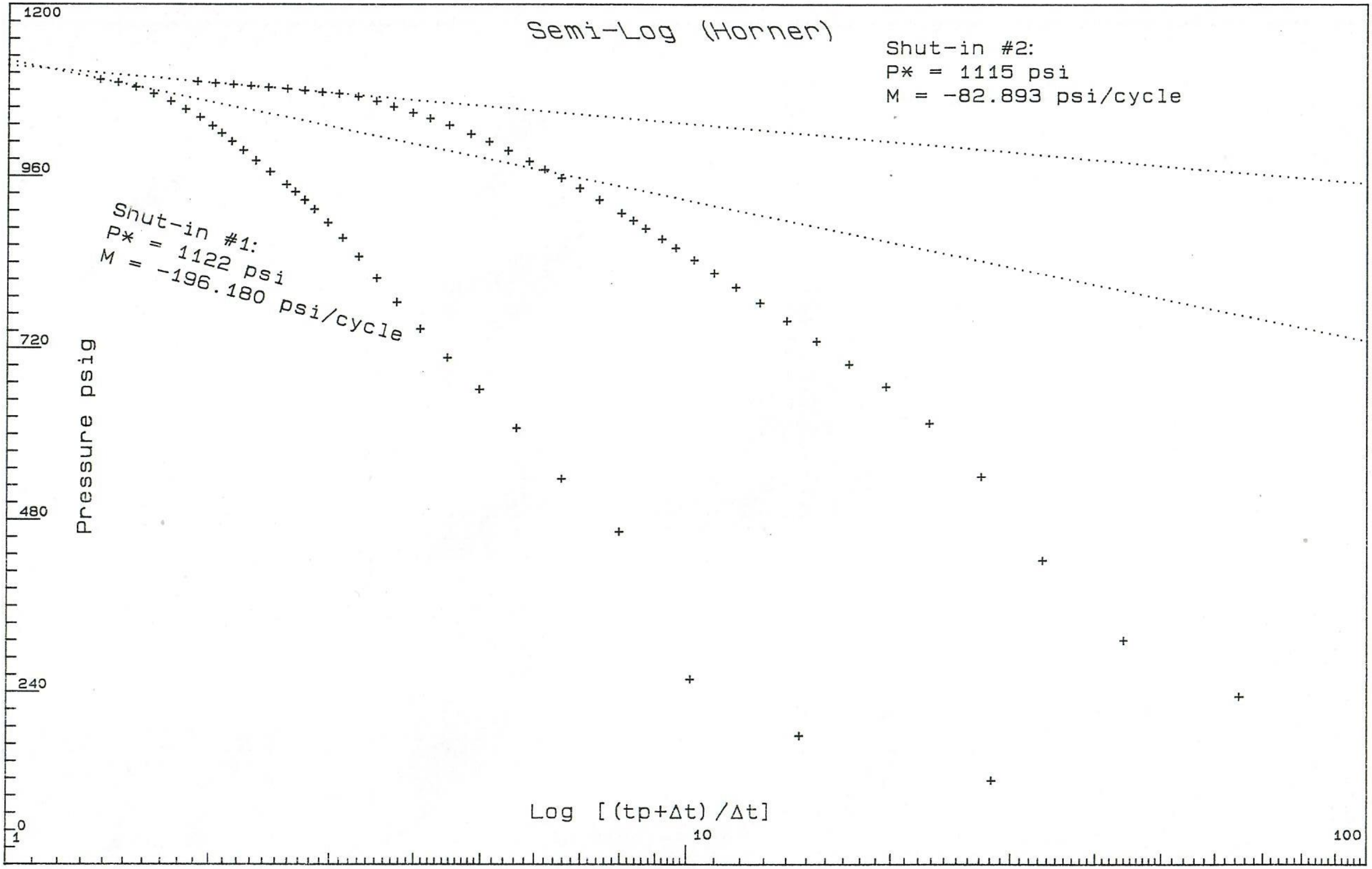
Sample RW: 5.0 @ 58 Deg F/1.94 @ Res Temp/1,275 ppm NaCl., 775 ppm Cl.

Resistivity

Make up Water		@		°F of Chloride Content		ppm.
Mud Pit Sample	3.0	@	60	°F of Chloride Content	2,112	ppm.
Gas / Oil Ratio		Gravity		°API @		°F

Where was sample drained On location.

Remarks:



Data Reporting Services

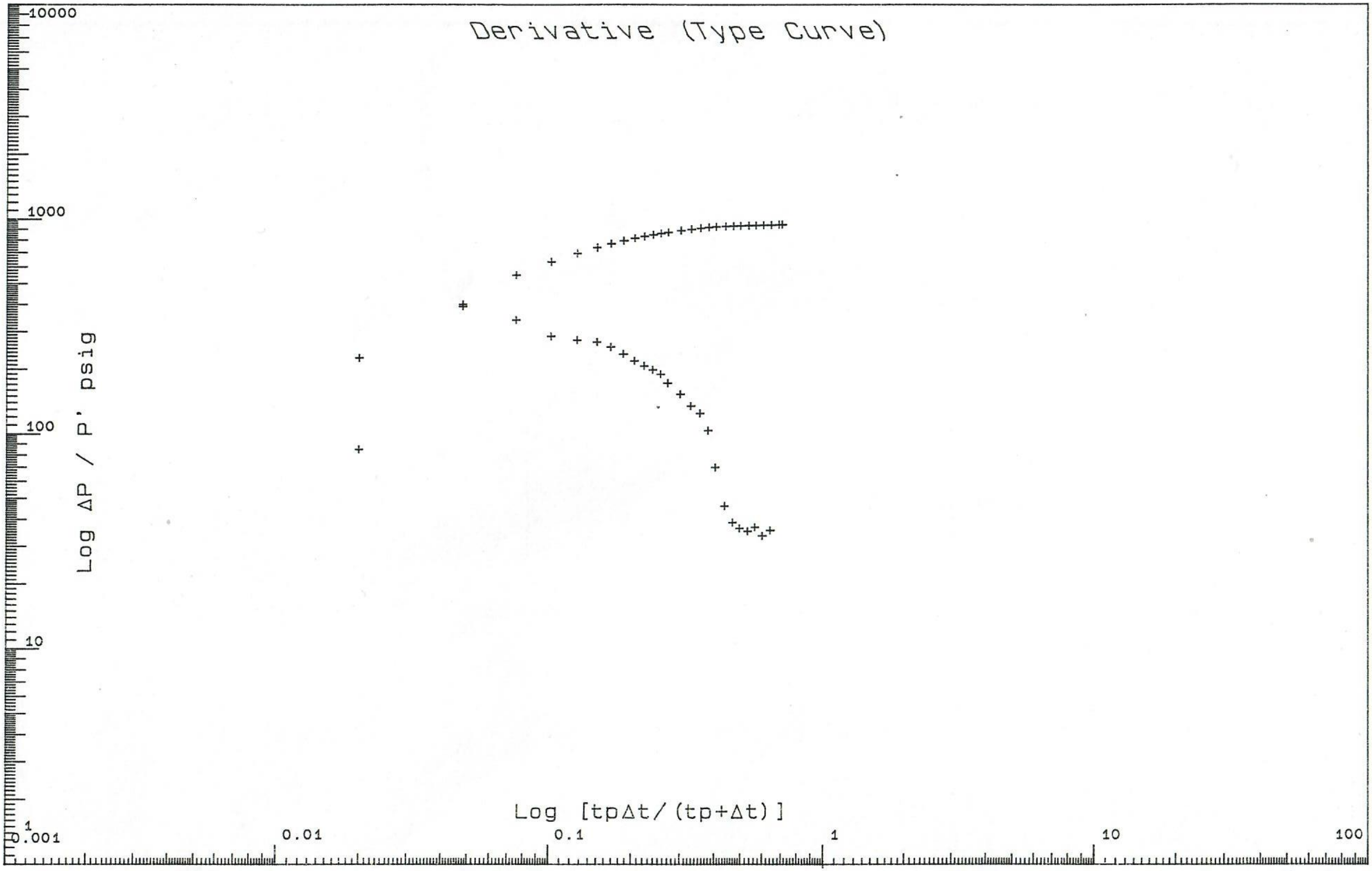
Company: Western Operating Co.
Well: Maddern #1-1, DST #1
Field: Roman Nose North

Date: 01/13/1997

Western Operating Co.
Maddern #1-1

DISTRIBUTION OF FINAL REPORTS

Western Operating Co. [5 + Disk]
518-17th St., Ste 1680
Denver CO 80202



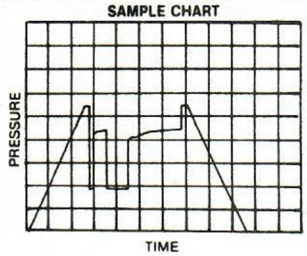
Data Reporting Services

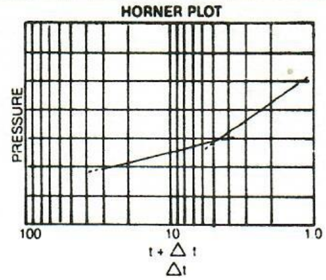
Company: Western Operating Co.
Well: Maddern #1-1, DST #1
Field: Roman Nose North

Date: 01/13/1997

Shut-in #2:

GUIDE TO DETECTION OF GEOLOGICAL ANOMALIES

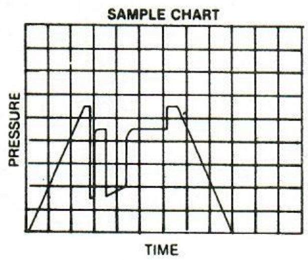


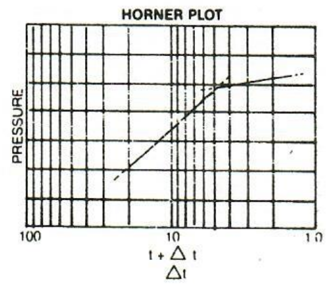


Horner Plot Slope Breaks Upward

Possible Causes

(1) decrease in pay thickness away from the wellbore
(2) decrease in permeability away from the wellbore
(3) increase in viscosity of reservoir fluid (fluid contact)
(4) barrier within the radius of investigation

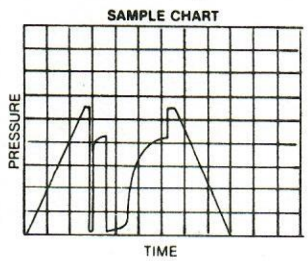


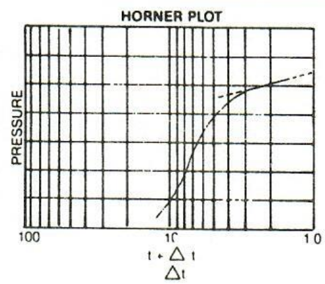


Horner Plot Slope Breaks Downward

Possible Causes

(1) increase in pay thickness away from the wellbore
(2) increase in permeability away from the wellbore
(3) decrease in viscosity away from the wellbore

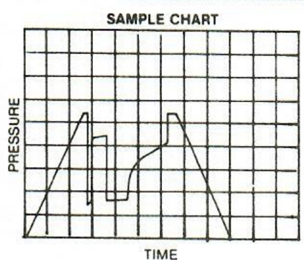


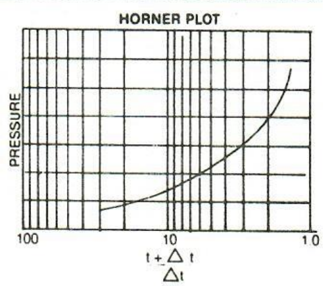


Early Time Deviation of Horner Plot

Possible Causes

(1) wellbore damage due to filtrate invasion, drilling solids, etc.
(2) partial penetration of pay zone
(3) plugging or choking of perforations (casing test only)
(4) wellbore storage effects (low permeability gas wells)

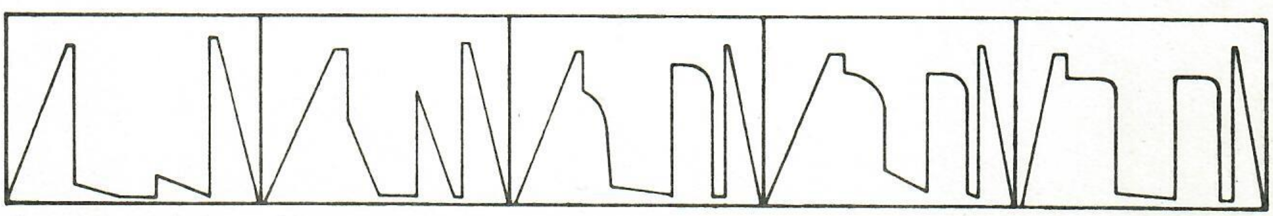




Horner Plot Slope Continually Increasing

Possible Causes

(1) well between two parallel boundaries (channel sand)
(2) induced hydraulic fractures



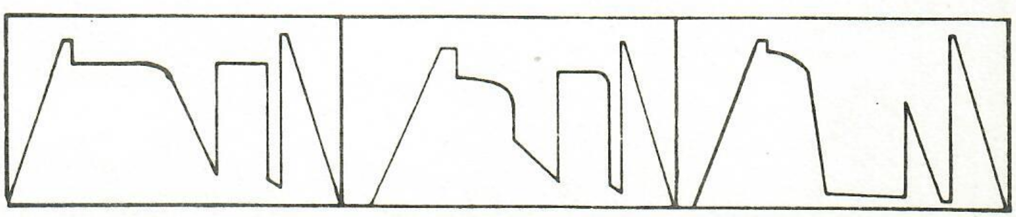
Very low permeability. Usually only mud recovered from interval tested. Virtually no permeability.

Slightly higher permeability. Again usually mud recovered.

Slightly higher permeability. Small recovery, less than 200 ft).

Average permeability. Final and initial shut-ins differ by 50 psi.

Average permeability. Strong damage effect. High shut-in pressure, low flow pressure.



Excelent permeability where final flow final shut-in pressure.

High permeability where ISIP and FSIP are within 10 psi.

Deep well bore invasion or damage. Final shut-in higher than the initial shut-in.