WORLD OF EXPERIENCE
JOHNSTON TESTERS
POST OFFICE BOX 36369 ■ HOUSTON, TEXAS 77036

December 3, 1965

Cactus Drilling Corporation
Drawer 71
San Angelo, Texas

RE: Formation Test No. 1
Navajo "A" No. 1
Field Report No. 17663-A

Gentlemen:

Enclosed are copies of the Productivity Log obtained during the above referenced test along with a complimentary Special Data Analysis.

The subject test was conducted utilizing our "MFE" and Productivity Logging system of tools. The recovery data indicate the formation contains hydrocarbons as 0.45 cu. ft. of gas was recovered in the "MFE" Sampler. The zone also produced gas to the surface during the formation test. The Special Data Analysis indicates the zone is tight, 0.16 Md., and apparently free of well bore damage.

The logs obtained "Before" and "After" test are presented for your review. The logs show good correlation features throughout the logged interval. However, it is not possible to pin-point the production interval due to a malfunction in the resistivity device on the "After" log. A connection came loose in the wiring system resulting in a shift, decrease, in the resistivity on the "After" log.

Please accept our appreciation for your use of this service.

Yours very truly,

A. T. Campbell Jr.

A. T. Campbell, Jr.
Manager, Interpretation and Evaluation

ATC:mc

JOHNSTON TESTERS

DYNAMIC EVALUATION INDICATOR

DEPLETION INDEX	
FORMATION DAMAGE	
FLUID TYPE	
FLOW RATE	
PERMEABILITY	
PRESSURE	
STIMULATION POTENTIAL	✓

YOUR PROFIT POTENTIAL IS	**QUESTIONABLE** ✓

CACTUS DRILLING CORPORATION
NAVAJO A #1, SAN JUAN COUNTY, NEW MEXICO
TEST #1, 6632' TO 6687'
FIELD REPORT #17663 A

More detailed information appears in the JOHNSTON SPECIAL DATA ANALYSIS

JOHNSTON TESTERS

MULTI-FLOW EVALUATOR (MFE)

Technical Report and

SPECIAL DATA ANALYSIS

The **Multi-Flow Evaluator** (MFE) is a wholly new formation evaluation tool that provides test data on an unlimited number of flow and shut-in pressure tests, plus a pressurized formation fluid sample under final flowing pressure. This sample may be drained at the well site, at our field location, or in your laboratory.

Johnston's **Special Data Analysis** provides valuable calculated data on reservoir pressure, flow capacity, effective permeability, well bore damage, radius of investigation, and potentiometric surface. Included also is a valuable written analysis of these data that can provide important help in planning your completion.

JOHNSTON TESTERS

SPECIAL DATA ANALYSIS

DECEMBER 2, 1965

GENTLEMEN:

THE ENCLOSED TEST APPEARS TO BE A GOOD MECHANICAL DRILL STEM TEST DURING WHICH THE TOOLS DID FUNCTION PROPERLY. THE FORMATION PRODUCED ENOUGH RESERVOIR FLUID FOR PROPER IDENTIFICATION. RESERVOIR PRESSURE DRAWDOWN WAS SUFFICIENT AND ADEQUATE SHUT-IN BUILD-UPS DID OCCUR FOR RELIABLE QUANTITATIVE ANALYSIS. AFTERFLOW WAS STILL IN EFFECT ON THE SECOND SHUT-IN BUILD-UP TO THE EXTENT THAT THIS DATA IS CONSIDERED UNRELIABLE FOR ANALYSIS.

1. FLOW RATE: A WEIGHTED AVERAGE FLOW RATE OF 800 MCF/DAY OF GAS WAS ESTIMATED FOR THIS TEST. THE DATA WERE INSUFFICIENT FOR DETERMINING AN ACCURATE FLOW RATE.

2. RESERVOIR PRESSURE: EXTRAPOLATION OF THE INITIAL SHUT-IN PRESSURE BUILD-UP INDICATES A MAXIMUM RESERVOIR PRESSURE OF 3460 P.S.I.G. AT RECORDER DEPTH. EXTRAPOLATION OF THE FINAL SHUT-IN PRESSURE BUILD-UP INDICATES A MAXIMUM RESERVOIR PRESSURE OF 3430 P.S.I.G. AT RECORDER DEPTH. THE DIFFERENCE BETWEEN THE INITIAL AND FINAL SHUT-IN PRESSURE OF 30 P.S.I. IS INSIGNIFICANT.

3. PERMEABILITY: THE CALCULATED TRANSMISSIBILITY FACTOR OF 125 MD.-FT./CP. INDICATES AN AVERAGE EFFECTIVE PERMEABILITY TO GAS OF 0.16 MD. FOR THE REPORTED 15 FOOT POROUS INTERVAL. THE CALCULATIONS WERE BASED ON A SLOPE OF 6,365,000 P.S.I.^{2}/LOG CYCLE OBTAINED FROM THE FINAL SHUT-IN BUILD-UP PLOT. IT WAS ASSUMED FOR THESE CALCULATIONS: (A) GAS GRAVITY 0.70 (B) VISCOSITY 0.023 CP. (C) AND GAS DEVIATION FACTOR 0.84. THESE FIGURES WERE OBTAINED FROM THE AVAILABLE TECHNICAL LITERATURE.

4. WELL BORE DAMAGE: THE CALCULATED ESTIMATED DAMAGE RATIO OF 0.40 INDICATES THAT NO WELL BORE DAMAGE IS PRESENT AT THE TIME AND CONDITIONS OF THIS TEST.

5. RADIUS OF INVESTIGATION: THE CALCULATED RADIUS OF INVESTIGATION OF THIS TEST IS 26 FEET BASED ON AN ASSUMED POROSITY OF 10%, COMPRESSIBILITY OF 2.2×10^{-4}, AND OTHER ASSUMPTIONS MADE IN NUMBER 3 ABOVE.

6. GENERAL COMMENTS: THE FORMATION EXHIBITS THE CHARACTERISTICS OF RELATIVELY LOW PERMEABILITY EFFECTIVE TO THE RESERVOIR FLUID AND INDICATES THE ABSENCE OF WELL BORE DAMAGE. IT IS SUGGESTED THAT THE RESULTS REPORTED HEREIN BE USED ONLY AS INDICATORS DUE TO THE ABSENCE OF ACCURATE FLOW RATE DATA.

A PRACTICAL COMPLETION IN THIS ZONE, IN MY OPINION, MAY BE ACHIEVED IF HEAVY STIMULATION, SUCH AS FRACTURING, WILL EFFECT AN INCREASE IN FLOW CAPACITY. LOCAL EXPERIENCE SHOULD DICTATE THE FEASIBILITY OF FRACTURING THIS ZONE.

A. T. Campbell Jr.

A. T. CAMPBELL, JR.
EVALUATION ENGINEER

CACTUS DRILLING CORPORATION
NAVAJO A #1, SAN JUAN COUNTY, NEW MEXICO
TEST #1, 6632' TO 6687'

FIELD REPORT #17663 A

JOHNSTON TESTERS

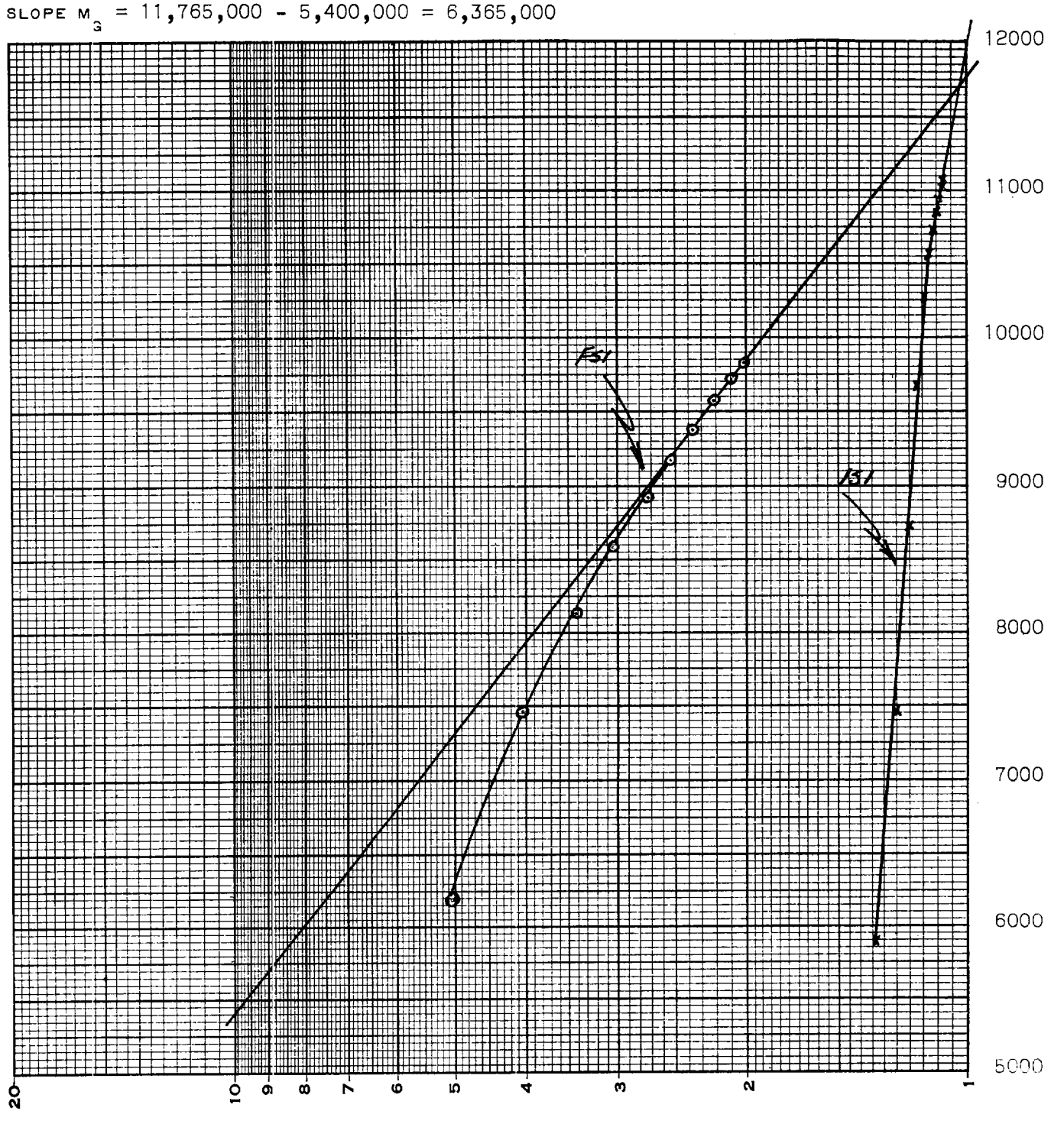
Instrument No. J-007

Gas Reservoir Engineering Data

Field Report No. 17663 A

Est mated Damage Ratio	EDR	0.40		Effective Transmissibility GAS	$\frac{Kh}{\mu Z}$	125	Md-ft./Cp.
Maximum Reservoir Pressure	P_o	3460	P.S.I.G.	Flow Rate (ESTIMATED) GAS	Q_g	800	MCF/Day
Slope of Shut-in Curve	M_g	6,365,000	PSI^2/log cycle	Flow Rate	Q		
Potentiometric Surface (Datum Plane, Sea Level)	PS	6288	ft.	Flow Rate	Q		
Radius of Investigation		26	ft.	K (Effective to GAS)		0.16	Md.

SLOPE M_G = 11,765,000 - 5,400,000 = 6,365,000



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Assumptions made for Calculations for Gas Recoveries

1. Q_g is taken as steady state flow and unless stated otherwise at standard conditions 14.7 P.S.I. and 60°F.
2. P_f is final formation flowing pressure at steady state flow.
3. Formation flow is taken as single phase flow. If liquid (condensate) is produced at surface, condensation is assumed to have occurred in drill pipe.
4. Radial flow is assumed.
5. Unless given, gas specific gravity is assumed to be 0.7 (air 1.0) and having pseudo critical temperature at 385° Rankin and pseudo critical pressure of 666 P.S.I.A.
6. Other standard radial flow, steady state assumptions.

Empirical Equations:

1. $EDR = \dfrac{P_o^2 - P_f^2}{M_g(\log T + 2.65)}$ where $M_g = \dfrac{P_1^2 - P_{10}^2}{\text{Log Cycle}}$

2. Transmissibility $\dfrac{Kh}{\mu Z} = \dfrac{1637^\circ T_f Q_g}{M_g}$

3. P.S. $= \left[P_o \times 2.309 \text{ ft./PSI}\right] - \left[\text{Recorder depth to sea level.}\right]$

4. Radius of Investigation, $r_i = \sqrt{\dfrac{Kt}{40\phi(1 - S_w)\mu c}}$ where t = time in days

Symbols		Dimensions
β	Formation volume factor	vol./vol.
c	Fluid compressibility	vol./vol./psi.
EDR	Estimated damage ratio	
ϕ	Formation porosity	fractional
h	Net producing interval	feet
J	Productivity index	Bbls./day/PSI
K	Permeability (effective)	Millidarcies
M_f	Slope of shut-in build up	PSI^2/log cycle
P_f	Final flowing pressure	PSIG
P_{fsi}	Final shut-in pressure at time t	PSIG
P_{isi}	Initial shut-in pressure	PSIG
P_o	Maximum reservoir pressure	PSIG
P_1	Final shut-in build up plot intercept @ 1	PSIG
P_{10}	Final shut-in build up plot intercept @ 10	PSIG
P.S.	Potent ometric surface	feet
Q	Rate of flow during test	Bbls./day

Symbols		Dimensions
Q_o	Rate of oil flow during test	Bbls./day
Q_w	Rate of water flow during test	Bbls./day
Q_g	Rate of gas flow during test	MCF/day
r_i	Radius of investigation	feet
r_w	Well bore radius	inches
S_w	Water saturation	%
t	Shut-in time period	minutes
Δt	Increment time of shut-in period	minutes
T	Open flow time period	minutes
$^\circ T_f$	Formation temperature	°Rankin
μ	Fluid viscosity (Reservoir conditions)	Centipoise
Z	Gas deviation factor (compressibility factor)	
$\dfrac{Kh}{\mu\beta}$ or $\dfrac{Kh}{\mu Z}$	Transmissibility factor	$\dfrac{\text{Md.} - \text{ft.}}{\text{Cp}}$

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 or 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.

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SURFACE INFORMATION

Description (Rate of Flow)	Time	Pressure (P.S.I.G.)	Surface Choke
Opened Tool (11-19-65)	2225	-	1"
STRONG BLOW			
GAS TO SURFACE	2227	30	"
CLOSED FOR INITIAL SHUT-IN	2230	-	"
FINISHED SHUT-IN	2330	-	"
RE-OPENED TOOL	2332	0	"
GAS 2000 MCF/DAY	2335	42	"
GAS	2340	23	"
GAS	2350	12	"
GAS (11-20-65)	0005	8	"
GAS	0015	6	"
CLOSED FOR SECOND SHUT-IN	0102	-	"
FINISHED SHUT-IN	0202	-	"
RE-OPENED TOOL	0204	-	"
GAS 1400 MCF/DAY	0205	38	"
GAS 1200 MCF/DAY	0208	30	"
GAS 800 MCF/DAY	0215	15	"
GAS	0234	8	"
CLOSED FOR FINAL SHUT-IN	0234	-	"
PULLED PACKER LOOSE	0434	-	"

RECOVERY DATA

Description	Amount
HEAVY GAS CUT MUD	110' (.54 BBLS)

EQUIPMENT, HOLE & MUD DATA

Type Test: M. F. E. PROD. LOG
Formation Tested: UPPER ISMAY (PENN)
Elevation: 4954 K.B. Ft.
Net Productive Interval: 15 Ft.
Estimated Porosity: - %
All Depths Measured From: KELLY BUSHINGS

EQUIPMENT SEQUENCE

COMPONENTS	Size/Type	Depth/Length/ I.D.
DRILL PIPE	4" FH	5971' / 3.2"
DRILL COLLARS	4½" XH	540' / 2.25"
CIRCULATING SUB	4½"	
DRILL COLLARS	4½" XH	90' / 2.25"
MULTI-FLOW EVALUATOR	5"	
BY-PASS VALVE	5" MFE	
JARS	3½" HS-1	
SAFETY JOINT	3½" BOWEN	
SAFETY SEAL	4½" MFE	
BOB-TAIL PACKER	6 3/4"	6625'
BOB-TAIL PACKER	6 3/4"	6632'
PERF. ANCHOR	4½" HVY	23'
RECORDER CARRIER	4½" J	6'
RECORDER CARRIER	4½" T	6'
PROD. LOG TOOL		20'

Total Depth: 6687 Ft.
Main Hole/Casing Size: 7 7/8"
Rat Hole/Liner Size: -
Bottom Choke Size: 5/8"
Mud Type: FRESH WATER GEL Wt. 11.0
Viscosity: 43 Water Loss: 8.0 C.C.

Cushion Type	Amount	Pressure
	NONE	

Remarks: LOCATION: 880' FEL, 550' FNL, SEC. 29, T-31-N, R-18-W

Address: DRAWER 71; SAN ANGELO, TEXAS

Company: CACTUS DRILLING CORPORATION Field: WILD CAT
Well: NAVAJO A #1 Location: SEE REMARKS
Test Interval: 6632' TO 6687' Test #: 1 Date: 11-19-65

County: SAN JUAN State: NEW MEXICO Field Report No.: 17663 A
Technician: BARTLETT (HOBBS) Test Approved By: MR. E. W. RUSSELL No. Reports Requested: 18 (4x's)

JOHNSTON TESTERS

MULTI-FLOW EVALUATOR
FLUID SAMPLE REPORT

Date 11-19-65 Field Report No. 17663 A

Company CACTUS DRILLING CORPORATION

Well NAVAJO A #1 Field WILD CAT

County SAN JUAN State NEW MEXICO

Test Interval 6632' To 6687' Test No. 1

Type of Test M. F. E. PROD. LOG Recovery Description 110' HEAVY GAS CUT MUD

Bot. Hole Temp. 148 °F.

Recorded Pressures:

ISI	* 3327	psig.
SSI	* 2799	psig.
FF	69	psig.
FSI	* 3137	psig.

Shut-in Pressure did not reach static reservoir pressure.

EVALUATOR SAMPLER UNIT

Sample Drained: ☒ On Location ☐ Service Center ☐ Other

☐ Laboratory-Name

Address

Sampler Pressure 75 psig. at Surface

Recovery:

Cu. Ft. Gas	.45
cc. Oil	-
cc. Water	-
cc. Mud	-
Total Liquid cc.	-

Gravity - °API - °F.

Gas/Oil Ratio -

	RESISTIVITY		CHLORIDE CONTENT
Recovery Water	- @ - °F.		- ppm.
Recovery Mud	- @ - °F.		
Recovery Mud Filtrate	- @ - °F.		- ppm.
Mud Pit Sample	1.6 @ 70 °F.		
Mud Pit Sample Filtrate	- @ - °F.		400 ppm.

Remarks THIS APPEARS TO BE A TEST OF A HYDROCARBON BEARING FORMATION.

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PRESSURE DATA

Instrument No.		J-007
Capacity (P.S.I.G.)		6400
Instrument Depth		6655'
Instrument Opening		INSIDE
Pressure Gradient P.S.I./Ft.		-
Well Temperature °F.		148
Initial Hydrostatic Mud	A	3748
Initial Shut-in	B	* 3327
Initial Flow	C	330
SECOND FLOW	C-3	78
SECOND SHUT-IN	B-1	* 2799
Final Flow	D	69
Final Shut-in	E	* 3137
Final Hydrostatic Mud	F	3710
Remarks:	C-1	188
	C-2	298
	C-4	245

Field Report No. 17663 A

TIME DATA

	Time Given	Time Computed
	60 Mins.	62 Mins.
	5 Mins.	5 Mins.
	90 Mins.	87 Mins.
	62 Mins.	62 Mins.
	30 Mins.	29 Mins.
	120 Mins.	121 Mins.

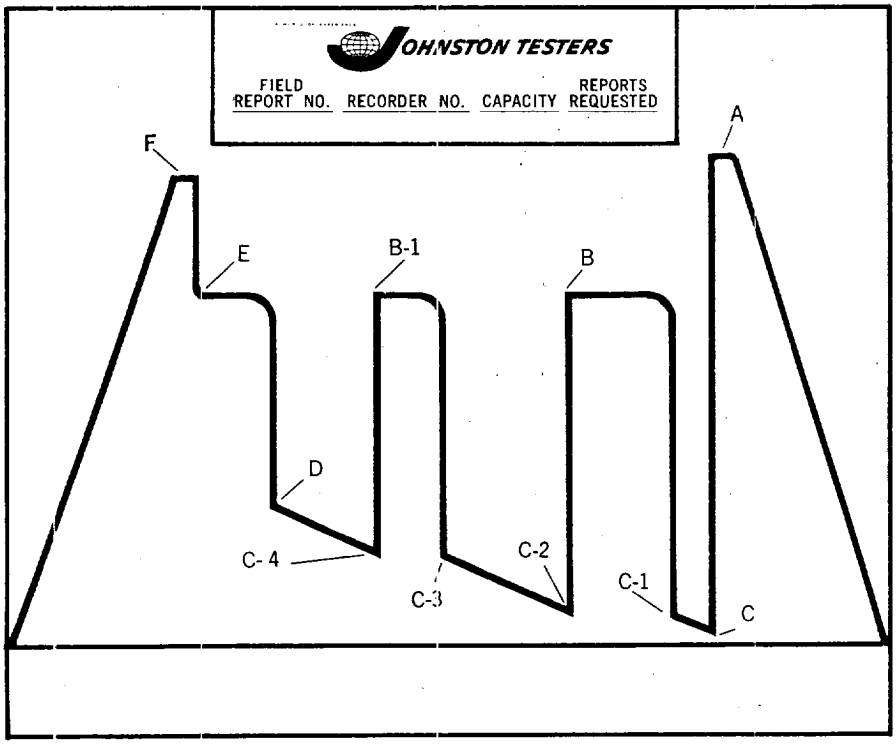
*Shut in pressure did not reach static reservoir pressure.

Clock Travel 0.02085 inches per min.

PRESSURE INCREMENTS

INITIAL SHUT-IN			SECOND SHUT-IN			FINAL SHUT-IN		
Point Minutes	Pressure	$\frac{T+\Delta t}{\Delta t}$	Point Minutes	Pressure	$\frac{T+\Delta t}{\Delta t}$	Point Minutes	Pressure	$\frac{T+\Delta t}{\Delta t}$
C-1 0	188		C-3 0	78		D 0	69	
5	1482	2.000	5	850	19.400	10	1308	13.100
10	2026	1.500	10	1303	10.200	20	2029	7.050
15	2428	1.333	15	1658	7.133	30	2487	5.033
20	2732	1.250	20	1926	5.600	40	2730	4.025
25	2955	1.200	25	2065	4.680	50	2850	3.420
30	3110	1.167	30	2189	4.067	60	2929	3.017
35	3204	1.143	35	2310	3.629	70	2986	2.729
40	3251	1.125	40	2425	3.300	80	3028	2.515
45	3277	1.111	45	2536	3.044	90	3062	2.345
50	3295	1.100	50	2646	2.840	100	3093	2.210
55	3308	1.091	55	2725	2.673	110	3117	2.100
60	3319	1.083	60	2797	2.533	120	3134	2.009
B 62	3327	1.080	B-1 62	2799	2.484	E 121	3137	2.000

GUIDE TO IDENTIFICATION OF DRILL STEM TEST PRESSURE CHARTS



A. Initial Hyd. Mud
B. Initial Shut-in
C. Initial Flow
D. Final Flow
E. Final Shut-in
F. Final Hyd. Mud

The following points are either fluctuating pressures or points indicating other packer settings, (testing different zones).

A-1, A-2, A-3, etc. Initial Hyd. Pressures
B-1, B-2, B-3, etc. Subsequent Shut-in Pressures
C-1, C-2, C-3, etc. Flowing Pressures
D-1, D-2, D-3, etc. Subsequent Final Flow Pressures
E-1, E-2, E-3, etc. Subsequent Final Shut-in Pressures
F-1, F-2, F-3, etc. Final Hyd. Mud Pressures
Z — Special pressure points such as pumping pressure recorded for formation breakdown.