1979 WORKOVER OPERATION

SOUTH BARROW WELL NO. 6

PERTINENT DATA

WELL NAME:	South Barrow Well No. 6
API NO.:	50-023-10015
LOCATION:	2483' FWL, 1337' FNL, NW 1/4, protracted Section 14, T22N, R18W, Umiat Meridian, Alaska
ELEVATION:	22.2' GL; 24' Casinghead; 42.2' (Est.) KB
PRESENT TOTAL DEPTH:	2365.5' Est. KB -2323.5' Subsea Datum

PHYSICAL MARKERS:

MARKER	EST. DEPTH KB
Casinghead	18.2'
Casing ID Restriction (ID ≈ 5-7/8")	1019.5'
5-1/2" Liner Top	2211.5'
TD	2365.5'
2-7/8" Tubing Shoe	2194.5'
2-3/8" Tubing Shoe	2354.5'

PROPOSED TESTING PROGRAM:	Section I
WORKOVER PROGRAM:	Section II
FINAL RESULTS:	Section III

SECTION I

PROPOSED TESTING PROGRAM

Four point backpressure tests are to be performed both before and after the workover of South Barrow Well No. 6 in order to evaluate the formation impact of the workover operation. Pressures are to be measured at the wellhead and flow rates at the flare via critical flow prover and dead weight tester.

1. The well is to be shut in and isolated from the gathering system. A flare line will be run to the flare pit and cribbed for positive drainage and staked to prevent movement. The well should remain shut in at least 48 hours before testing. A standard four point flow after flow backpressure test will be run, limiting drawdown as much as possible while obtaining adequate pressure spread.

2. After completion of the workover procedure and cleanup of the well, a second test will be made. This test may be terminated after two rates if the data are in close agreement with the results of the first test.

SECTION II

WORKOVER PROGRAM

INTRODUCTION

A letter written on January 1, 1978 by Andy Crane detailed suspicious noises which were coming from the South Barrow Well No. 6 and which were speculated to be caused by parted tubing. A decision was made to implement a workover program on the well in order to determine the nature of the "noises" coming from the wellbore. Husky Oil NPR Operations, Inc. was designated as the operator for the workover program.

Husky prepared an engineering program for the workover, moved the Brinkerhoff Signal, Inc. Rig No. 31 on the site and began operations on April 10, 1979 by rigging up to kill the well.

OPERATIONS HISTORY

DATE AND FOOTAGE DRILLED AS OF 6:00 A.M.	ACTIVITY
4/10/79	Rig up to kill well.
4/11/79	Kill well with 9.0 ppg $CaC1_2$ workover fluid.
4/12/79	Set wireline tubing plug. Remove old tubing tree. Install new tubing head. Install blowout preventer. Test rams to 3,000 psi, Hydril to 1,500 psi. Pulled and laid down old tubing. Laid down two 2-7/8" x 10" pup joints, 70 joints 2-7/8" tubing, 2-7/8" x 2-3/8" cross over, one 2-3/8" x 5' pup joint, and five joints 2-3/8" tubing.
4/13/79	Run 7" casing scraper to 800'. Set retrievable bridge plug at 750'. Test tubing head flange seals to 2,000 psi. Pulled and plugged outlets on old tubing head. Retrieved bridge plug. Ran Schlumberger Borehole Geometry log. Log indicated casing ID restriction to 5.4" from 1052' to 1072'. Ran in hole with 2-7/8" tubing and circulate to condition hole.
4/14/79	Ran 78 joints 2-7/8" tubing with six centralizers and two 1/4" chemical injection lines. Landed tubing at 2353.94'; centralizers at 1210', 1514', 1805', 1983', 2193', and 2339'; and injection lines at 1500' and 2000'. Nippled down blowout preventer and nippled up tubing tree. Tested tree to 3,000 psi.

4/15/79	Displaced workover fluid from well with nitrogen.
4/16/79	Nippled up to flow well. Flowed to clean up well.
4/17/79	Flow to clean well.
4/18/79	Rigged down and released rig.
4/19/79 to 5/9/79	Prepared location for well house. Installed house, SSV, production connections, power lines, etc.
5/10/79	Returned well to production.

SECTION III

FINAL RESULTS

The South Barrow Well No. 6 was placed back into production on May 10, 1979. The AOF was 2.100 MMCFGPD with a Productivity Index of 5.217 MCF/D/psi. The pre-workover AOF was 5.850 MMCFGPD with a Productivity Index of 14.44 MCF/D/psi. A 64% decrease in deliverability resulted from the workover operation (see attached memo by Stephen K. Lewis).

M E M O R A N D U M

Nov. 22, 1978

TO: FILE

Further considerations with respect to the supply and demand situation in the South Barrow Gas Field in consideration of the proposed workover of well no. 6.

When the decision to work Well # 6 over was made it was assumed that the tubing in Well # 6 was parted and that this would prevent liquid removal by blowdowns. The well was expected to experience a decline in deliverability and to eventually water off.

It was also assumed that the remaining wells could make up for the loss of Well No. 6 while it was being worked over and that the winter demand would follow normal patterns.

Since early spring there have been several developments which create some doubt as to the validity of these assumptions.

First, Well # 6 does not appear to be watering off and the tubing might in fact not be parted. The well has been blown down twice since the initial incidence of "subterranean rumbling." The first blowdown on April 15, 1978 recovered water for seven seconds. The blowdown of October 14, 1978 recovered water for six seconds. These recoveries were in keeping with the wells past performance and would be hard to explain the case of parted tubing.

From October 1977 to October 1978, the average shutin wellhead pressure of the field declined 33.493 psi. The shut in well head pressure of Well No. 6 declined 30.235 psi. During the same period the average wellhead flowing pressure declined 43.511 psi while that of Well No. 6 declined 35.0 psi. These declines are in keeping with past field performance and indicate that there has been no unusual build up of fluids in Well No. 6. The field average shutin pressure of October 1978 was 748.75 psia. The shutin wellhead pressure of Well No. 6 was 756.86 psia.

In October 1977 Well No. 6 produced an average of 472 McF/d. The October 31,1977 rate was 554 McF/d flowing at 750 psig on an 18/64" choke. The February 1978 rate was 465 McF/d at 740 psig against a 18/64" choke. The October 1978 average daily rate was 464 McF/d. The October 31, rate was 412 McF/d at 715 psig against a 20/64 choke.

Thus, there is no evidence of radical change in the pressure, flow, or fluid production in Well No. 6 and sudden failure is doubtful.

The assumption that the demand normally supplied by Well No. 6 could be evenly distributed to the remaining wells has proven false. This is due to both the mechanics of the gathering system and the behavior of the individual wells.

Figure I is a generalized schematic of the gathering system. Wells 5,7,8, & 11 flow against positive chokes under critical flow conditions. Flow rate is a function of upstream pressure and choke size and is insensitive to fluctuations in line pressure. Wells 6, 9, and 10 also have positive chokes. These chokes are not in critical flow and rate is sensitive to downstream pressure. Operationally the primary controller senses line pressure at point A and is set to maintain 220 psig at A. Pressure drop at A will cause the controller to open and lower the pressure at B and C. Pressure drop at B will not increase the flow rate from wells 5,7, 8, and 11 as they are in critical flow across the positive chokes. The secondary controller is set to sense and maintain 220 psig at point C. When it senses the pressure drop at C it will open and drop the line pressure down stream of the chokes on wells 6, 9, & 10. This will result in an increase in the flow from these wells as their chokes are not in critical flow. If this increase is unsufficient to increase the pressure at C to 220 psig the secondary controller will continue to drop the pressure at D and the rate will increase until critical flow is achieved at the chokes. At this point the rate will stabilize as controlled by choke sizes and flowing wellhead pressures.

If this rate is less than demand the distribution system pressure will fall.

Figure II is the gathering system flowing pressure with the demand and flow balanced. Figure III represents the system when demand exceeds supply.

Wells 5, 7, 8, and 11 are currently producing at rates close to their operational maximum. Well No. 5 is constantly on the verge of failure by watering off, and Wells 7, 8, and 11 are already close to a 10 percent drawdown. The choke size on these wells should not be increased to any large amount. Thus the production loss from shutting in Well #6 will be born primarily by wells 9 & 10. If this is the case and 10% drawdown is not exceeded on any well the system deliverability without Well No. 6 would be 2625 McF/d. This value is less than the projected December demand by 554 McF/d and less than the projected peak demand by 843 McF/d.

Previous demand projections have assumed that major construction in Barrow does not occur during the winter. This year this is not the case. There are currently eight, twelve-unit apartment buildings and thirteen single family dwellings under construction. The combined furnace input ratings of these buildings is 14,870,000 BTU/HR. Assuming an 80% efficiency and 75% load the projected consumption of these new buildings is 214.128 McF/d This is an increase of 8.89% over the average 1977 daily consumption due to these projects alone. As the previous projected rate of increase in peak demand has been 5.5% per year it becomes apparent that the village is engaged in a rate of growth which may well invalidate previous demand projections.

Considering the facts that Well No. 6 does not appear to be in a state of failure, that the swing capacity of the field is limited primarily to wells 9 & 10, and that demand projections may be conservative, it becomes questionable whether a work over of Well No. 6 during the peak demand season is indeed prudent operational procedure.

Stephen K Lewis

S. K. Lewis

cc: Jack McCarthy w/attachment

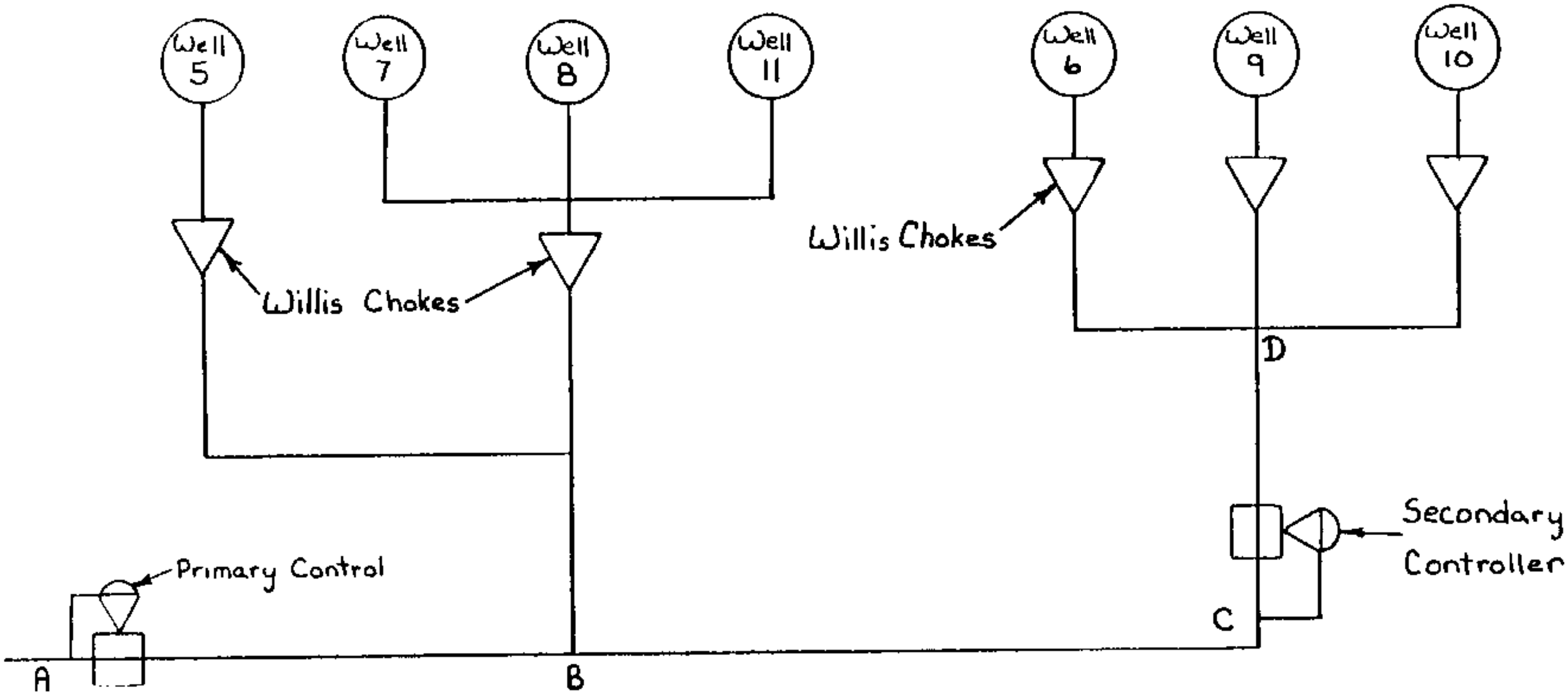


Figure I

General Gathering

System Schematic

South Barrow Gas Field

SKL 11/22/78

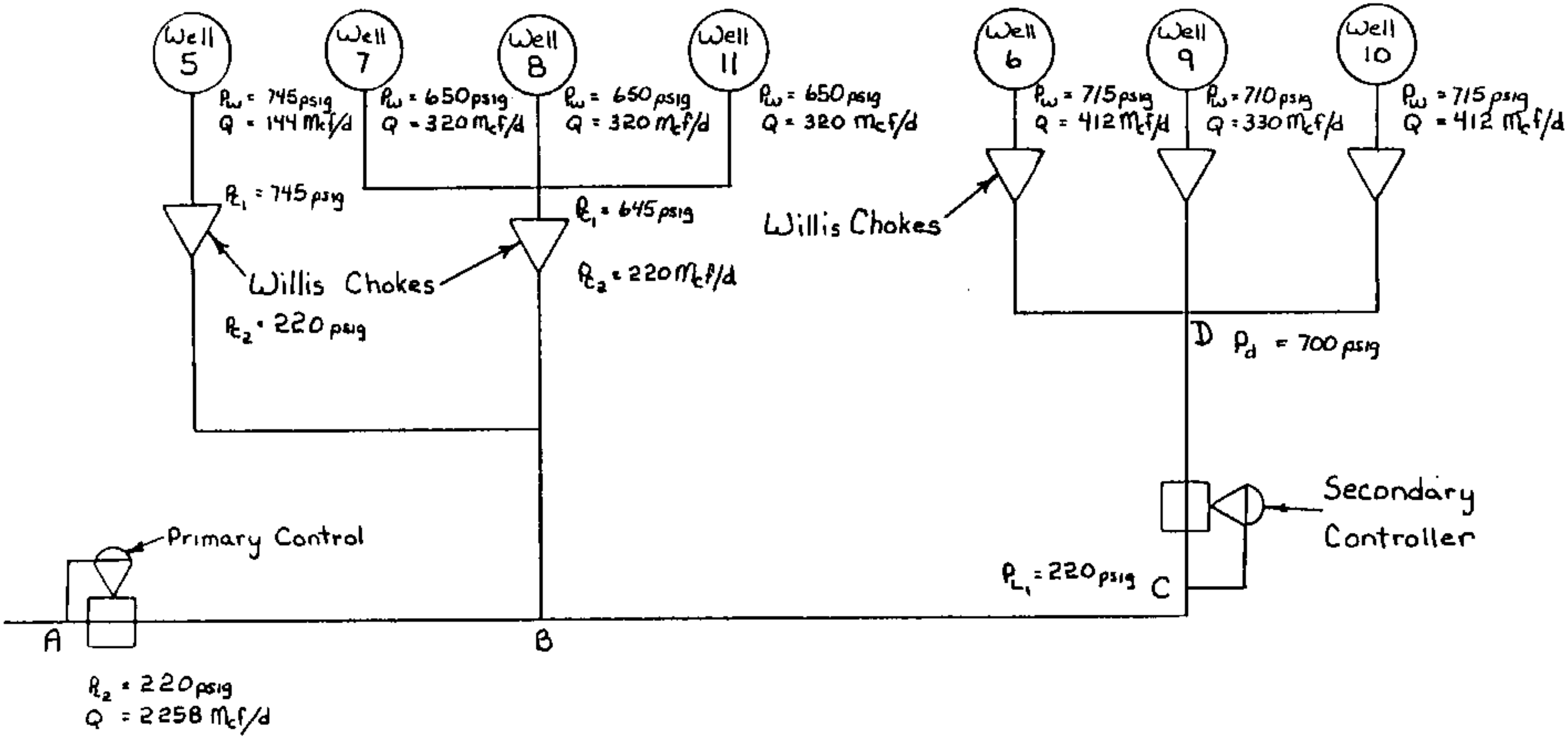


Figure II

Generalized Gathering

System Schematic

South Barrow Gas Field

Production Equal Demand

SKL 11/22/78

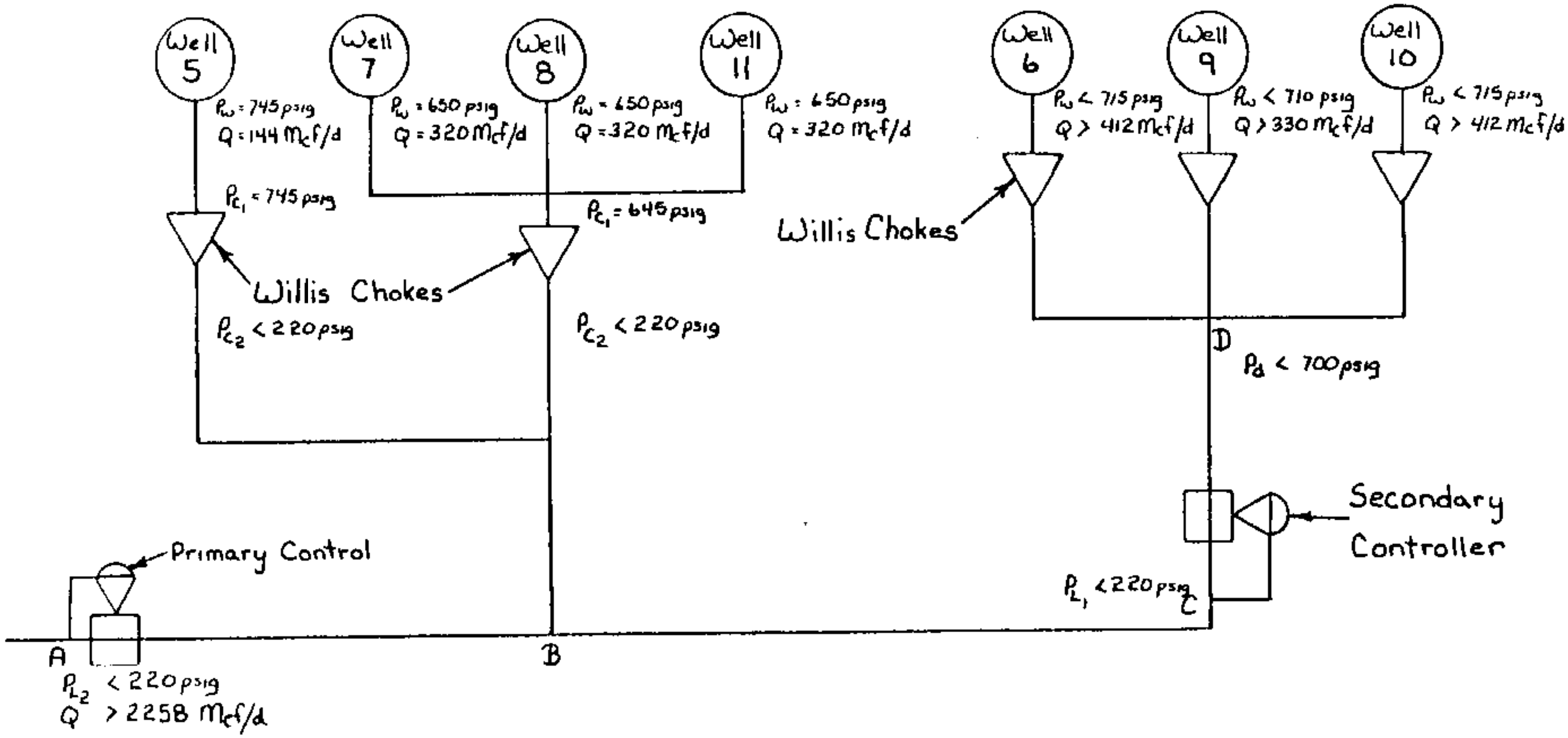


Figure III

Generalized Gathering

System Schematic

South Barrow Gas Field

Production Is Less Than Demand

SKL 11/22/78

SOUTH BARROW WELL NO. 6
LOSS OF DELIVERABILITY DUE TO WORKOVER PROCEDURE

South Barrow No. 6 was tested before and after being killed for the replacement of tubing. Stabilized Four Point tests were performed with surface pressures recorded and flow measured by Critical Flow Prover.

The pre-workover AOF was 5.850 M^2cF/d with a Productivity Index of 14.44 McF/d/psi. Post-workover AOF was 2.100 M^2cF/d with a Productivity Index of 5.217 McF/d/psi. Based on the ratio of Calculated Productivity Indices, South Barrow No. 6 suffered a 64% decrease in deliverability due to the workover operation.

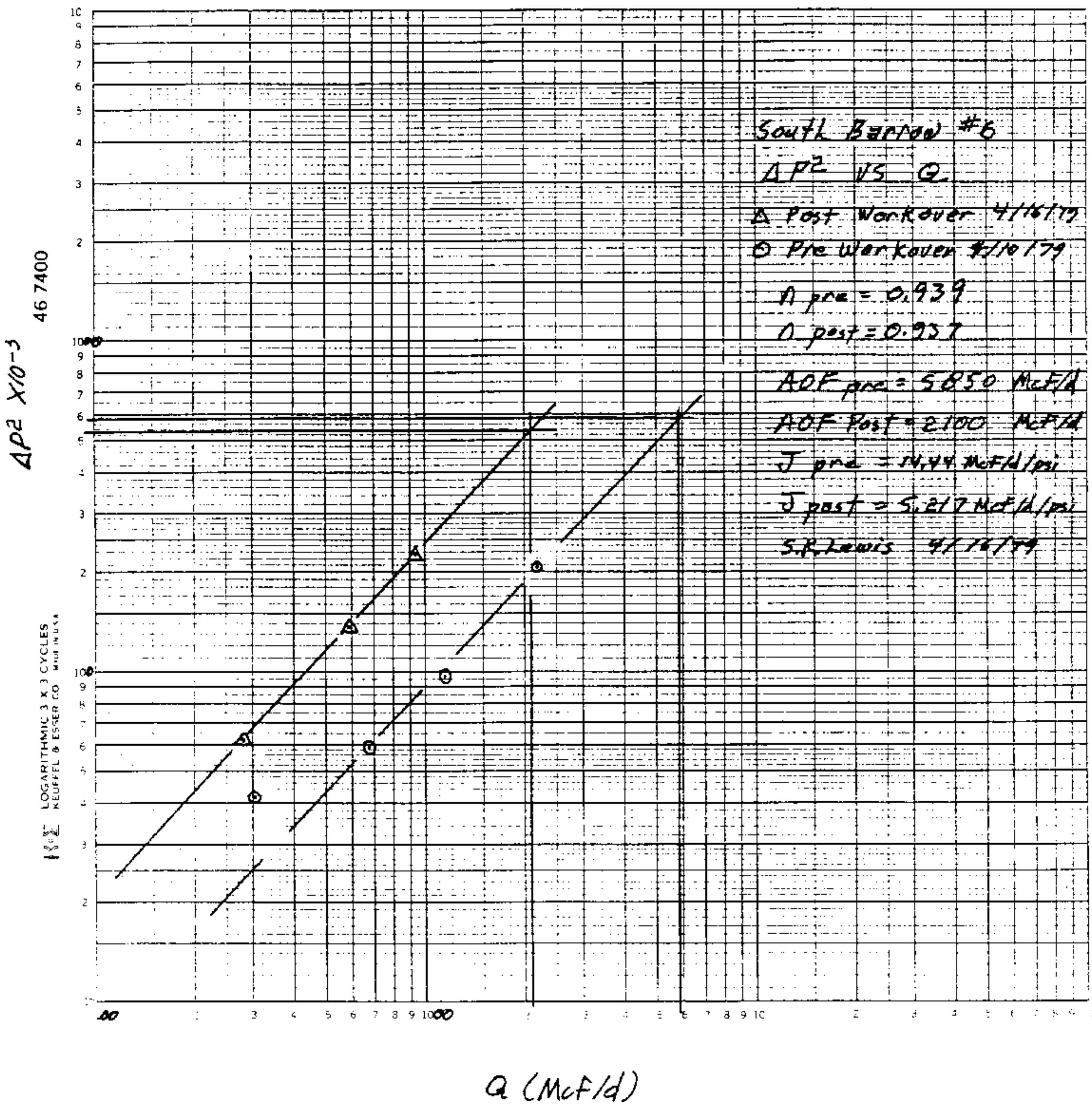
The loss of deliverability is primarily attributable to the loss of 60 bbls of workover fluid to the formation during the workover operation.

The risk of such loss of fluid and resultant formation damage was documented by Husky and brought to the attention of the USGS prior to the implementation of workover operations.

Backpressure data are attached.

S. K. Lewis
Senior Engineer

Copy to: J. McCarthy


South Barrow #6
ΔP² VS Q
Δ Post Workover 4/16/79
⊙ Pre Workover 4/10/79
n pre = 0.939
n post = 0.937
AOF pre = 5850 McF/d
AOF Post = 2100 McF/d
J pre = 14.44 McF/d/psi
J post = 5.217 McF/d/psi
S.R. Lewis 4/16/79
ΔP² X10⁻³
46 7400
LOGARITHMIC 3 X 3 CYCLES
KEUFFEL & ESSER CO.
Q (Mcf/d)

FIELD DATA SHEET

Pre Workover
Equal time, 4 Point

Type Test: ☐ Initial ☐ Annual ☒ Special		Test Date 4/10/79		Lease No. or Serial No.
Company Husky Oil NPR Operations Inc		Connection		Allottee
Field South Barrow	Reservoir Upper + Lower Barrow Sands	Location		Unit
Completion Date 3/24/64	Total Depth 2365.5	~~Plug Back~~ TD 2365.5	Elevation 22.2' GL 42.2' KB	Farm or Lease Name
Csg. Size 7	Wt. 20	d 6.184	Set At 2278.5	Well No. South Barrow #6
Perforations: 5½" Liner	From 2211.5	To 2365.5		
Tbg. Size 2⅞	Wt. 6.5	d 2.441	Set At 2353	Sec. 14 Twp – Blk T22N Rge – Sur R18W UM
~~Perforations:~~ Slots	From 2279	To 2336		
Type Completion (Describe) Dual Zone Comingled Gas			Packer Set At None	County or Parish North Slope
Producing Thru Annulus	Reservoir Temp. F 67 @ 2300	Mean Annual Temp. F 11.5	Baro. Press. – P 30.54 P_b=15.0	State Alaska
L 2308	H 2308	G_g 0.565	% CO_2 0.18 · % N_2 0.84 · % H_2S –	Prover ~~Meter Run~~ ~~Taps~~ 2"

DATE Time of Reading	ELAP. TIME Hrs.	WELLHEAD WORKING PRESSURE Tbg. Psig	Csg. Psig	Temp. F	METER OR PROVER Pressure Psig	Diff.	Temp. F	Orifice	REMARKS (Include liquid production data: Type – API Gravity – Amount)
09:35	0		745					8/64	
10:05	0.5		722	30	718		9		
10:35	1.0		722	30	718		9		
11:05	1.5		721	30	718		9		
11:35	2.0		722	29	717		9	8/64	Shut In to Change Choke
11:48	0							12/64	
12:18	0.5		711	27	707		22		
12:48	1.0		710	27	706				
13:18	1.5		709	27	705		25		
13:48	2.0		708	27	705		20	12/64	Shut in to Change Choke
13:55	0		720					16/64	
14:25	0.5		687	26	683		22		
14:55	1.0		685	26	681		22		
15:25	1.5		683	26	680		22		
15:55	2.0		683	26	679		22	16/64	Shut in to Chang Choke
16:01	0		712					24/64	
16:31	0.5		615	25	607		22		
17:01	1.0		611	25	599		22		
17:31	1.5		606	25	596		22		
18:01	2.0		602	24	595		18		
18:31	2.5		607	24	592		19		
19:01	3.0		605	24	592		19	24/64	Shut in

PAGE 1 OF 1 DATA BY SK Lewis

Form BPT 1

MULTIPOINT BACK-PRESSURE TEST REPORT

Pre Workover

Equal time 4 Point

Type Test: ☐ Initial ☐ Annual ☒ Special	Test Date 4/10/79
Lease No. or Serial No.	
Company Husky Oil NPR Operations Inc	Connection
Allottee	
Field South Barrow	Reservoir Upper + Lower Barrow Sands	Location
Unit	
Completion Date 3/24/64	Total Depth 2365.5	Plug Back TD 2365.5	Elevation 22.26 GL 42.21 KB
Farm or Lease Name	
Csg. Size 7	Wt. 29	d 6.184	Set At 2278.5	Perforations: From 5½" liner 2211.5	To 2365.5
Well No. South Barrow #6	
Tbg. Size 2⅞	Wt. 6.5	d 2.441	Set At 2353	Perforations: From Slots 2279	To 2336
Sec. 14	Twp-Blk T22N	Rge-Sur R18W UM
Type Completion (Describe) Dual Zone Comingled Gas	Packer Set At None
County or Parish North Slope	
Producing Thru Annulus	Reservoir Temp. F 62 @ 2308	Mean Annual Temp. F. 11.5	Baro. Press. - P 30.54" B=15.8
State Alaska	
L 2308	H 2308	G_g 0.565	% CO_2 0.18	% N_2 0.84	% H_2S —
Prover 2"	Meter Run	Taps

NO.	FLOW DATA Prover Line Size	X Choke Orifice Size	Press. psig	Diff. h_w	Temp. F	TUBING DATA Press. psig	Temp. F	CASING DATA Press. psig	Temp. F	Duration of Flow, Hr.
SI	2"		745							
1.		8/64	717		9			722	29	
2.		12/64	705		20			708	27	
3.		16/64	679		22			683	26	
4.		24/64	594		18			607	24	
5.										

NO.	Coefficient (24-Hour)	$\sqrt{h_w P_m}$	Pressure P_m	Flow Temp. Factor, F_t	Gravity Factor, F_g	Super Compress. Factor F_{pv}	Rate of Flow Q, Mcfd
1.	0.2716		732.33	1.053	1.330	1.0795	300.659
2.	0.6237		720.33	1.041	1.330	1.0704	665.818
3.	1.115		694.33	1.039	1.330	1.0664	1140.849
4.	2.439		609.33	1.043	1.330	1.0573	2179.709
5.							

NO.	P_r	Temp. R	T_r	Z
1.	1.090	469	1.388	0.8582
2.	1.072	480	1.420	0.8728
3.	1.033	482	1.426	0.8793
4.	0.907	479	1.417	0.8945
5.				

Gas Liquid Hydrocarbon Ratio ______ Mcf/bbl
API Gravity of Liquid Hydrocarbons ______ deg.
Specific Gravity Separator Gas ______ x x x x x x x x x x x
Specific Gravity Flowing Fluid x x x x x x ______
Critical Pressure 672 psia ______ psia
Critical Temperature 338 R ______ R

P_c 760.33 P_c^2 578102 P_f ______ P_f^2 ______

NO.	P_t	P_t^2	$P_c^2-P_t^2$	P_w	P_w^2	$P_c^2-P_w^2$	P_s	P_s^2	$P_f^2-P_s^2$
1.	732.33	536307	41795						
2.	720.33	518875	59226						
3.	694.33	482094	96008						
4.	609.33	371332	206770						
5.									

AOF 5850 mcfd
n .939

Commission ______
Company S.K. Lewis
Others ______

Form BPT 5

FIELD DATA SHEET

Post Workover
Equal time 4 Point

Type Test: ☐ Initial ☐ Annual ☒ Special	Test Date: 4/16/79
Lease No. or Serial No.:	
Company: Husky Oil NPR Operations Inc.	Connection:
Allottee:	
Field: South Barrow	Reservoir: Upper + Lower Barrow Sands
~~Location~~:	Unit:
Completion Date: 3/24/64	Total Depth: 2365.5
~~Plug Back~~ TD: 2365.5	Elevation: 22.2' GL 42.2' KB
Farm or Lease Name:	
Csg. Size: 7	Wt.: 29#
d: 6.184	Set At: 2278.5
~~Perforations~~: 5 ½" Slotted liner	From – To: 2211.5 – 2365.5
Well No.: South Barrow #6	
Tbg. Size: 2 7/8	Wt.: 6.5#
d: 2.441	Set At: 2353'
~~Perforations~~: Slots	From: 2279 To: 2336
Sec.: 14	Twp – Blk: T22N
Rge – Sur: R18W UM	
Type Completion (Describe): Dual Zone comingled gas	Packer Set At: None
County or Parish: North Slope	State: Alaska
Producing Thru: Annulus	Reservoir Temp. F: 62 @ 2300
Mean Annual Temp. F: 11.5°	Baro. Press. – P_a: 30.32" [illegible]
L: 2308	H: 2308
G: 0.565	% CO_2: 0.18
% N_2: 0.84	% H_2S: —
Prover: 2"	~~Meter Run~~ ~~Taps~~

DATE Time of Reading	ELAP. TIME Hrs.	WELLHEAD WORKING PRESSURE Tbg. Psig	Csg. Psig	Temp. F	METER OR PROVER Pressure Psig	Diff.	Temp. F	Orifice	REMARKS (Include liquid production data: Type – API Gravity – Amount)
14:30	0	715	715		0			8/64	
15:15	.75	683	679	34	676				
15:30	1.0	683	679	33	674		17		
16:00	1.5	681	675	34	673		15		
16:30	2.0	681	678	35	671		11	8/64	Shut in to Change Choke
16:42	0	700	697	28	0			12/64	Open to New Choke
17:12	.5	625	620	27	618		17		
17:42	1.0	623	619	27	612		15		
18:15	1.5	625	619	27	614		9		
18:42	2.0	625	619	27	614		9	12/64	Shut in to Change Choke
18:49	0	673	667	28	0			16/64	Open to New Choke
19:19	.5	558	550	25	545		9		
19:4	1.0	555	546	26	540		8		
20:19	1.5	553	544	27	540		8		
20:49	2.0	555	548	27	539		7	16/64	Shut in

Test terminated as next available Choke size of 24/64 would have Resulted in drawdown in excess of 75%

PAGE 1 OF 1 DATA BY S.K. Lewis

Form BPT 1

MULTIPOINT BACK-PRESSURE TEST REPORT

Post Workover
Equal time 4 point

Lease No. or Serial No.

Type Test: ☐ Initial ☐ Annual ☒ Special — Test Date 4/16/79

Company: Husky Oil NPR Operations Inc. — Connection	Allottee
Field: South Barrow — Reservoir: Upper + Lower Barrow Sands — ~~Location~~	Unit
Completion Date: 3/24/64 — Total Depth: 2365.5 — ~~Plug Back~~ TD: 2365.5 — Elevation: 22.2' GL 42.2' KB	Farm or Lease Name
Csg. Size: 7" — Wt.: 29# — d: 6.184 — Set At: 2228.5 — ~~Perforations:~~ From: 5½" Slotted Liner 2211 — To: 2365.5	Well No.: South Barrow #6
Tbg. Size: 2⅞" — Wt.: 6.5# — d: 2.441 — Set At: 2353 — Perforations: From: Slots 2279 — To: 2336	Sec. 14 — Twp - Blk T22N — Rge - Sur R18W UM
Type Completion (Describe): Dual Zone Comingled Gas — Packer Set At: None	County or Parish: North Slope
Producing Thru: Annulus — Reservoir Temp. F: 62 @ 2308 — Mean Annual Temp. F.: 11.5 — Baro. Press. - P: 30.32" P_a=15.22	State: Alaska
L: 2308 — H: 2308 — G_g: 0.565 — % CO_2: 0.18 — % N_2: 0.84 — % H_2S: —	Prover: 2" — ~~Meter Run~~ ~~Taps~~

NO.	Prover Line Size	X Choke Orifice Size	FLOW DATA Press. psig	Diff. h_w	Temp. F	TUBING DATA Press. psig	Temp. F	CASING DATA Press. psig	Temp. F	Duration of Flow Hr.
SI						715		715		
1.	2"	8/64	671		11	681		678	35	2
2.		12/64	614		9	625		619	27	2
3.		16/64	539		7	555		548	27	2
4.										
5.										

NO.	Coefficient (24-Hour)	$\sqrt{h_w P_m}$	Pressure P_m	Flow Temp. Factor, F_t	Gravity Factor, F_g	Super Compress. Factor F_{pv}	Rate of Flow Q, Mcfd
1.	0.2716		686.22	1.051	1.330	1.072	279.282
2.	0.6227		629.22	1.053	1.330	1.067	586.439
3.	1.115		554.22	1.055	1.330	1.059	918.262
4.							
5.							

NO.	P_r	Temp. R	T_r	Z
1.	1.021	471	1.393	0.8702
2.	0.936	469	1.388	0.87897
3.	0.825	467	1.382	0.89088
4.				
5.				

Gas Liquid Hydrocarbon Ratio ________ Mcf/bbl
API Gravity of Liquid Hydrocarbons ________ deg.
Specific Gravity Separator Gas ________ | x x x x x x x x x x x
Specific Gravity Flowing Fluid x x x x x x | ________
Critical Pressure 672 psia | ________ psia
Critical Temperature 338 R | ________ R

P_c 730.22 P_c^2 533221 — P_f ________ P_f^2 ________

NO.	P_t	P_t^2	$P_c^2-P_t^2$	P_w	P_w^2	$P_c^2-P_w^2$	P_s	P_s^2	$P_f^2-P_s^2$
1.	686.22	470898	62323						
2.	629.22	395918	137303						
3.	554.22	307160	226081						
4.									
5.									

AOF 2.10 Mcfd
n .937

Commission ________
Company S. K. Lewis
Others ________

Form BPT 5