gulram, inc.

2828 12th street nw, suite C
p.o. box 6548
albuquerque, new mexico 87197-6548

petroleum engineering and government regulation consultants

505-345-2351

August 15, 1985

REPORT TO KIMBELL OIL CO. OF TX
FLOWRATE REQUIRED TO PREVENT SKIN DAMAGE OF THE
SALAZAR WELL NO. 4-E
SE¼NW¼ section 34,T.25N.,R.6W., N.M.P.M., Rio Arriba County, NM

SUMMARY

The Salazar Well No. 4-E produces from the Basin Dakota Reservoir, which is subject to irreversible formation (skin) damage if the well remains shut-in over an extended period without production. Producing the well on a regular interval is necessary to remove the water from the well-bore, which can interact with the clay constituents of the Dakota reservoir rocks and cause skin damage. Using the radial flow equation for gas, and setting the pressure drop for skin damage to zero, results in the required flow rate to prevent that damage from occurring and the possible loss of productive reserves. Based upon the June deliverability test, the required flowrate would be 13,550 MCF/month. Thus, this well must be produced for 5 days each month or a volume of about 13,550 MCF to prevent permanent damage.

FORMATION CHARACTERISTICS

The Salazar Well No. 4-E is being produced from the Basin Dakota formation. The basal Dakota "...deposits consist of dark-gray carboneaceous shales, a few thin coal seams, some siltstones, and thin channel sandstones."[1] The next unit consists of "...dark carbonaceous shales, mudstones, and thin siltstones and sandstones ..."[1] The clay materials present in the shales of this formation are capable of migration and clogging of the formation pore spaces if contacted by foreign water or altered formation water (ionic environment shifts are sufficient).

FORMATION DAMAGE

When the clay particles of a formation are disturbed or rearranged, it is impossible to restore the original pore configuration or "permeability." This formation damage should be prevented, since a complete cure is not possible with subsequent well treatments.

Formation damage occurs with the hydration or dehydration of swellable clays, which are present throughout the Dakota formation. The damage mechanism is the reduced "relative permeability," which results from water "wetting" the formation rock. The clay particles swell and move into the pore spaces, "clogging" them, and thus reduce the open space available for the hydrocarbons to travel to the well-bore. The critical area for damage to the formation is the first few feet away from the bore-hole, which affects the radial flow of the hydrocarbons into the hole. In radial flow systems, any reduction in the permeability around the well-bore can result in permanent loss of productivity.

Also, sandstone formations, as excellent depth filters, are highly sensitive to flow rate and pressure differentials. Increased water saturation near the well-bore will cause filtrate invasion or coning of the formation water, which creates a water blockage to hydrocarbon flow. This type of blockage can be corrected by regular water production.

Thus, to prevent permanent damage to the formation and effectively eliminate water blockage, the well must be produced to remove the water from the productive formation face or "skin" in the well-bore. The most effective treatment of well damage is prevention not corrective well treatments after the damage occurs.

FLOWRATE REQUIRED TO PREVENT DAMAGE

To prevent entrapment of reserves in a potentially productive zone, since irreversible formation damage can restrict or prevent effective depletion, we must determine an adequate flow rate to minimize skin damage to this well by removal of formation water.

Using the radial flow equation for gas wells, we will set the p_{skin} (pressure drop due to skin damage) to zero and use the data from the 1985 well deliverability test report dated 6-12-85, which reflects the well's current undamaged condition. We will assume a radial drainage impact of 160 acres for a Dakota well; permeability (undamaged) equal to the pool average; and molecular weight of the gas to be 21.65 since test results show the gas to be "dry with a trace of condensate", indicating that the stream is not pure methane, but contains some liquids. See attached calculation pages for the details of the analysis. The calculation results in a flow rate of 444.34 MCF/day or 13,552 MCF per month. Based upon the 6-12-85 deliverability of 2698 MCF/day, this results in 5.02 days per month.

Thus, this well should be allowed to produce approximately 13,550 MCF per month or 5 days, to prevent permanent formation damage and loss of productive reserves.

Sue E. Umshler

Sue E. Umshler, P.E.

REFERENCES

1. W.F. Hoppe, 1978, Basin Dakota Gas Field in Oil & Gas Fields of the Four Corners Area: Four Corners Geological Society, pgs. 204-206.

2. Thomas O. Allen & Alan P. Roberts, 1978, Production Operations, Volume 2, Oil and Gas Consultants, Inc., pgs 95-107.

3. H.C. Slider, 1976, Practical Petroleum Reservoir Engineering Methods, PennWell Books.

4. Craft & Hawkins, 1959, Applied Petroleum Reservoir Engineering, Prentice Hall, Chemical Engineering Series.

$$q_{gas} = \frac{.703\, K_{und}\, h\, (p_e^2 - p_w^2 - \Delta P_{skin}^2)^n}{\mu\, T_F\, z\, \ln\left(\frac{r_e}{r_w}\right)}$$

q_g = flow rate, mcf/day
K_{un} = undamaged permeability, Darcies
h = net thickness, feet
p_e = External Boundary pressure (initial shut-in), psia
p_w : Flowing pressure (FTP), psia
ΔP_{skin} = pressure drop in damaged zone, psia
μ = viscosity, cp
r_e : external Boundary radius (ultimate drainage impact), feet
r_w = well radius, feet
T_F = formation Temperature, °R
z = gas deviation

Given: T_f = 180°F + 460 = 640°R (well log)
$K_{Basin\ DK}$ = .175 md avg or .000175 Darcies (Pool Report)
h = 90 feet (Completion Report)
r_e = 1490 feet (160 acre drainage radius)
r_w = .7 feet (Completion Report)
P_e = 1350 psia (back plot of SICP vs. Cum)
6-12-85 well Test Data (well deliverability curve)
p_w = 787 psia
gravity = .704 ⟹ by charts μ = .016 cp
z = .885

Calculate n

$$n = \frac{w}{29(\text{gravity})}$$

Gas is dry w/ trace condensate so Assume MW

assume gas

w methane = 16.04 70%
w ethane = 30.07 20%
w propane = 44.09 10%

Weighted average w = 16.04(.70) + 30.07(.20) + 44.09(.10) = 21.65

So

$$n = \frac{21.65}{\ldots} = 1.06$$

Set $\Delta P_{skin} = 0$ to determine q_g required to prevent damage to zone.

Calculate q_g.

$$q_g = \frac{.703\,(.000175)(90)(1350^2 - 787^2 - 0^\circ)^{1.06}}{.016\,(6H0)(.885)\ln\left(\frac{1490}{.7}\right)}$$

$$= 444.34 \text{ mcf/day}$$

Monthly production

$q_m = 444.34 \times 30.5 =$ 13552.37 mcf/mon.

Deliverability on 6-12-85 was 2698 mcf/day

Calculate No. days for flow

$13552.37 \div 2698 =$ 5.02 days per month

Sue E. Umbles
8-13-85

NEW MEXICO OIL CONSERVATION COMMISSION
WELL DELIVERABILITY TEST REPORT FOR 19 85

Form C122-A
Revised 1-1-65

POOL NAME	POOL SLOPE	FORMATION	COUNTY
Basin Dakota	n= .75	Dakota	Rio Arriba

Meter No. 94-932

COMPANY			WELL NAME AND NUMBER		
Kimbell Oil Company of Texas			Salazar No. 4B		
UNIT LETTER	SECTION	TOWNSHIP	RANGE	PURCHASING PIPELINE	
F	34	25N	6W	El Paso Natural Gas Co.	
CASING O.D. - INCHES	CASING I.D. - INCHES	SET AT DEPTH - FEET	TUBING O.D. - INCHES	TUBING I.D. - INCHES	TOP - TUBING PERF. - FEET
4.500	4.000	6759	2.375	1.995	6422
GAS PAY ZONE		WELL PRODUCING THRU		GAS GRAVITY	GRAVITY X LENGTH
FROM 6422 TO 6672		CASING	TUBING X	.704	4521
DATE OF FLOW TEST			DATE SHUT-IN PRESSURE MEASURED		
FROM 5/27/85 TO 6/4/85			6/18/85		

PRESSURE DATA - ALL PRESSURES IN PSIA

(a) Flowing Casing Pressure (DWt)	(b) Flowing Tubing Pressure (DWt)	(c) Flowing Meter Pressure (DWt)	(d) Flow Chart Static Reading	(e) Meter Error (Item c - Item d)	(f) Friction Loss (a - c) or (b - c)	(g) Average Meter Pressure (Integr.)
932	787	262	256	+6	525	259
(h) Corrected Meter Pressure (g + e)	**(i) Avg. Wellhead Press. P_t = (h + f)**	**(j) Shut-In Casing Pressure (DWt)**	**(k) Shut-In Tubing Pressure (DWt)**	**(l) P_c = higher value of (j) or (k)**	**(m) Del. Pressure**	**(n) Separator or Dehydrator Pr. (DWt) for critical flow only**
265	787	1322	1322	1322	P_d = 40 %P_c 529	784

FLOW RATE CORRECTION (METER ERROR)

Integrated Volume - MCF/D	Quotient of $\frac{\text{Item c}}{\text{Item d}}$	$\sqrt{\frac{\text{Item c}}{\text{Item d}}}$	Corrected Volume
2035	1.0234	1.0116	Q = 2059 MCF/D

WORKING PRESSURE CALCULATION

$(1-e^{-s})$	$(F_c Q_m)^2 (1000)$	$R^2 = (1-e^{-s})(F_c Q_m)^2(1000)$	P_t^2	$P_w^2 = P_t^2 + R^2$	$P_w = \sqrt{P_w^2}$
.280	374,759	104,933	619,369	724,302	851

DELIVERABILITY CALCULATION

$$D = Q\left[\frac{P_c^2 - P_d^2}{P_c^2 - P_w^2}\right]^n = 2059\left[\left(\frac{1,467,843}{1,028,483}\right)^n = (1.4341)^n = 1.3105\right] = 2698 \text{ MCF/D}$$

REMARKS:

This well has critical flow -
Use FTP (b) for P_t (i)

SUMMARY

Item h	265	Psia
P_c	1322	Psia
Q	2059	MCF/D
P_w	851	Psia
P_d	529	Psia
D	2692	MCF/D

Company Kimbell Oil Company of Texas
By E. A. Clement
Title Prod. Supt.
Witnessed By
Company

(Rev. 5-63)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SUBMIT IN DUPLICATE (See other instructions on reverse side)

Form approved.
Budget Bureau No. 42-R355.5.

WELL COMPLETION OR RECOMPLETION REPORT AND LOG*

5. LEASE DESIGNATION AND SERIAL NO.: SF-080136
6. IF INDIAN, ALLOTTEE OR TRIBE NAME:
7. UNIT AGREEMENT NAME:
8. FARM OR LEASE NAME: Salazar
9. WELL NO.: 4-E
10. FIELD AND POOL, OR WILDCAT: Basin Dakota
11. SEC., T., R., M., OR BLOCK AND SURVEY OR AREA: Sec. 34-T25N-R6W
12. COUNTY OR PARISH: Rio Arriba
13. STATE: NM

1a. TYPE OF WELL: OIL WELL ☐ GAS WELL ☒ DRY ☐ Other
b. TYPE OF COMPLETION: NEW WELL ☒ WORK OVER ☐ DEEP-EN ☐ PLUG BACK ☐ DIFF. RESVR. ☐ Other

2. NAME OF OPERATOR: Curtis J. Little
3. ADDRESS OF OPERATOR: P.O. Box 1258 Farmington, NM 87499
4. LOCATION OF WELL (Report location clearly and in accordance with any State requirements)*
At surface: 1630' FNL & 1460' FWL
At top prod. interval reported below
At total depth: Same

API # - 30-039-23368

14. PERMIT NO. — DATE ISSUED

15. DATE SPUDDED: 1-16-84
16. DATE T.D. REACHED: 1/27/84
17. DATE COMPL. (Ready to prod.): 2/21/84
18. ELEVATIONS (DF, RKB, RT, GR, ETC.)*: 6378' GR
19. ELEV. CASINGHEAD: 6378'

20. TOTAL DEPTH, MD & TVD: 6753'
21. PLUG, BACK T.D., MD & TVD: 6717'
22. IF MULTIPLE COMPL., HOW MANY*:
23. INTERVALS DRILLED BY: → ROTARY TOOLS: 0-6753' CABLE TOOLS:

24. PRODUCING INTERVAL(S), OF THIS COMPLETION—TOP, BOTTOM, NAME (MD AND TVD)*: 6422-6672 KB Dakota

25. WAS DIRECTIONAL SURVEY MADE: No

26. TYPE ELECTRIC AND OTHER LOGS RUN: IES, GR-CNL-Density

27. WAS WELL CORED: No

28. CASING RECORD (Report all strings set in well)

CASING SIZE	WEIGHT, LB./FT.	DEPTH SET (MD)	HOLE SIZE	CEMENTING RECORD	AMOUNT PULLED
8-5/8"	28	222 KB	12-1/4"	145 sx. (171 cuft. slurry)	none
4-1/2"	11.6	6759	7-7/8"	DV Tool 4574, 600 sx. Poz (774 cuft.) Bond top 5458 KB. 2nd Stage w/375 sx. & 75 sx. Class B (1891 cuft.) Top cmt.: 1300 KB	

29. LINER RECORD

SIZE	TOP (MD)	BOTTOM (MD)	SACKS CEMENT*	SCREEN (MD)

30. TUBING RECORD

SIZE	DEPTH SET (MD)	PACKER SET (MD)
2-3/8	6548	

31. PERFORATION RECORD (Interval, size and number)

6632-72 KB, 21 holes, 0.33" dia. 24" apart.
6548-76 KB, 6514-28, 6432-36, 6422-26, 29 holes, 0.33" dia. 24" apart.

32. ACID, SHOT, FRACTURE, CEMENT SQUEEZE, ETC.

DEPTH INTERVAL (MD)	AMOUNT AND KIND OF MATERIAL USED
6632-72 Acidize	1200 gals. HCL, 41500 lbs. sd., 62930 gals. gel, BDP 2450 psi, ATP 3200 psi, AIR 28 BPM, ISIP 2100 psi. 6576-6422 Acidize 1700 gal. HCL, 60000 lbs. sd., 93780 gals. gel, BDP 1900 psi ATP 3400 psi, AIR 31 BPM, ISIP 2550 psi

33.* PRODUCTION

DATE FIRST PRODUCTION	PRODUCTION METHOD (Flowing, gas lift, pumping—size and type of pump)	WELL STATUS (Producing or shut-in)
2/21/84	Flowing	SI

DATE OF TEST	HOURS TESTED	CHOKE SIZE	PROD'N. FOR TEST PERIOD →	OIL—BBL.	GAS—MCF.	WATER—BBL.	GAS-OIL RATIO
2/21/84	3	3/4"		Trace	623	Trace(Frac	

FLOW. TUBING PRESS.	CASING PRESSURE	CALCULATED 24-HOUR RATE →	OIL—BBL.	GAS—MCF.	WATER—BBL.	OIL GRAVITY-API (CORR.)
391	787		Trace	4984	0	

34. DISPOSITION OF GAS (Sold, used for fuel, vented, etc.): To be sold
TEST WITNESSED BY: Joe Elledge

35. LIST OF ATTACHMENTS: None

36. I hereby certify that the foregoing and attached information is complete and correct as determined from all available records.

SIGNED Curtis J. Little TITLE Operator DATE 2/22/84

*(See Instructions and Spaces for Additional Data on Reverse Side)

General: This form is designed for submitting a complete and correct well completion report and log on all types of lands and leases to either a Federal agency or a State agency, or both, pursuant to applicable Federal and/or State laws and regulations. Any necessary special instructions concerning the use of this form and the number of copies to be submitted, particularly with regard to local, area, or regional procedures and practices, either are shown below or will be issued by, or may be obtained from, the local Federal and/or State office. See instructions on items 22 and 24, and 33, below regarding separate reports for separate completions.

If not filed prior to the time this summary record is submitted, copies of all currently available logs (drillers, geologists, sample and core analysis, all types electric, etc.), formation and pressure tests, and directional surveys, should be attached hereto, to the extent required by applicable Federal and/or State laws and regulations. All attachments should be listed on this form, see item 35.

Item 4: If there are no applicable State requirements, locations on Federal or Indian land should be described in accordance with Federal requirements. Consult local State or Federal office for specific instructions.

Item 18: Indicate which elevation is used as reference (where not otherwise shown) for depth measurements given in other spaces on this form and in any attachments.

Items 22 and 24: If this well is completed for separate production from more than one interval zone (multiple completion), so state in item 22, and in item 24 show the producing interval, or intervals, top(s), bottom(s), and name(s) (if any) for only the interval reported in item 33. Submit a separate report (page) on this form, adequately identified, for each additional interval to be separately produced, showing the additional data pertinent to such interval.

Item 29: *"Sacks Cement":* Attached supplemental records for this well should show the details of any multiple stage cementing and the location of the cementing tool.

Item 33: Submit a separate completion report on this form for each interval to be separately produced. (See instruction for items 22 and 24 above.)

37. SUMMARY OF POROUS ZONES:
SHOW ALL IMPORTANT ZONES OF POROSITY AND CONTENTS THEREOF; CORED INTERVALS; AND ALL DRILL-STEM TESTS, INCLUDING DEPTH INTERVAL TESTED, CUSHION USED, TIME TOOL OPEN, FLOWING AND SHUT-IN PRESSURES, AND RECOVERIES

FORMATION	TOP	BOTTOM	DESCRIPTION, CONTENTS, ETC.
Ojo Alamo	1450	1522	Probably Water

38. GEOLOGIC MARKERS

NAME	TOP MEAS. DEPTH	TOP TRUE VERT. DEPTH
Ojo Alamo	1450	Same
Kirtland	1522	Same
Fruitland	2033	Same
Pictured Cliffs	2158	Same
Lewis	2252	Same
Cliff House	3713	Same
Menefee	3761	Same
Point Lookout	4368	Same
Mancos	4508	Same
Gallup	5502	Same
Greenhorn	6310	Same
Graneros Shale	6371	Same
Graneros Sand	6411	Same
Dakota	6512	Same

U.S. GOVERNMENT PRINTING OFFICE: 1965—O-683436
GPO 837-497

871-233