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APPLICATION OF THE GASGUN™ IN KANSAS OIL AND GAS OPERATIONS

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Executive Summary

The frequency of using the GasGun™ to stimulate oil and gas wells in Kansas has increased significantly in the past two years. Explosive stimulation of wells is nearly as old as the oil business. However, the GasGun™ incorporates modern science and techniques to provide a safer, more controllable stimulation, which is also relatively inexpensive.

Kansas operators have applied the GasGun™ in over 240 wells with a wide range of results. The technique has been applied in limestone and sandstone in widely scattered regions of the state. Many wells which were uneconomical have been revived and many years of commercial production is anticipated.

Not all wells are candidates, nor are all treatments successful. The developer of the process has relied upon the successes and failures to establish screening criteria for determining logical stimulation candidates.

Introduction

The GasGun™ is a stimulation treatment for oil and gas wells that utilizes a low, solid- propellant explosive to generate high-pressure gas and create fractures in reservoirs. Developed by J Integral Engineering, Inc., of West Linn, Oregon, and Sandia National Laboratories, the process has had reasonable success in the Illinois Basin and recently, over 240 applications have been conducted in Kansas.

The tool, which is normally run on wireline, contains a solid propellant, that rapidly generates high-pressure gas when it burns. Multiple fractures radiating 10 to 100 feet from the wellbore are created by the progressively-burning propellants, which are much more effective at creating fractures than high explosives such as nitroglycerine.

The GasGun comes in a standard diameter of 3¼" and in lengths of 2, 4, 6, 8 and 10 feet. The treatment can be performed in cased wells or open-hole completions.

The advantages of the GasGun over hydraulic fracturing is that there is minimal vertical growth of fractures, multiple fractures are created, the entire zone is stimulated, there is no need to inject fluids, less equipment is needed, and the cost is much lower. While not considered as a complete replacement for hydraulic fracturing or acidizing, it has applicability in many marginal wells where the expense of a fracture treatment can not be justified, or as an initial treatment prior to acidizing or fracturing.

In Kansas, one operator has been successful in utilizing the GasGun to stimulate tight sections in the Arbuckle, allowing for low-pressure acid treatments. In a recent application, six wells were shot with the GasGun, and only one was considered to be unsuccessful, as it broke into the water zone. Three of the

treatments were obvious successes. Over a period of two months, the combined production of the three wells rose from 8.7 BOPD prior to treating to 30 BOPD. Due to the relatively inexpensive cost of the treatments, payout often occurs in days or weeks. The operator is continuing to monitor the wells and will soon be performing similar treatments on additional wells.

The same operator utilized the process to complete a Simpson sandstone well that was tight in the producing zone and was underlain by an aquifer. After perforating and stimulating the well with the GasGun, the well was hydraulically fractured at lower than normal pressure and no communication with the aquifer occurred.

A well in Russell County was stimulated with two 4' GasGuns on top of a bridge plug at depth of 2385'. This Tarkio limestone well went from 0 to 5 barrels of oil per day with a considerable quantity of gas.

Other zones treated include the Mississippian, Pawnee, Fort Scott, Altamont, Bartlesville, Burgess, and Cherokee

Experiences in other states indicate the process has applicability in limestone, sandstone or shale, and possibly coal.

Bottom Line

Stimulating Arbuckle producers presents special challenges. Apply too much horsepower and, even if just acidizing, one can easily find the ocean. Hydraulic fracturing produces a fracture that follows the path of least resistance, and, in the Arbuckle, experience shows that that path is vertically down into the water-bearing zone. Gas-generating, solid-propellant stimulation treatments using GasGun™ technology are proving to be one option that can produce fractures that stay in the zone treated and avoid finding the water.

For many formations, a GasGun treatment alone may be enough stimulation. In the Arbuckle, producers are using these treatments to produce a fracture network in the formation that provides a conduit for a subsequent acid treatment. The acid typically goes in on vacuum and increases oil production with little or no change in the percentage of water production. As of July 2003, 240 GasGun treatments have been conducted in Kansas including 70 in the Arbuckle dolomite. Economic success has been achieved in approximately 70% of these wells with a two- to three- fold increase in oil production normal. In a few cases, production increase has been 10 to 22 times the before-treatment rate.

History

Early in the history of the oil industry, many wells were stimulated with high explosives. But problems of wellbore damage, safety hazards and unpredictable results caused usage to decline. Extensive research on solid propellants that deflagrate rather than detonate has led to safe and more effective options.

Building on research conducted at Sandia National Laboratories in the early 1970s and a DOE Small Business Innovation Research grant, one such option, known as the GasGun™, became commercially available in July 1998.

What is the GasGun?

The GasGun uses solid propellant, often referred to as a low explosive, to generate high-pressure gas at a rapid rate. The rate is tailored to the formation characteristics to be rapid enough to create multiple fractures radiating 10 to 100 feet from the wellbore, but not so rapid as to pulverize and compact the rock as is experienced with classic high explosives, such as nitroglycerine. The star-shaped pattern of multiple fractures removes wellbore damage or blockage and increases the formation permeability near the wellbore.

The propellant used is similar to that used in large-bore military guns. While the concept of using solid

propellants to stimulate oil and gas wells is not entirely new, the GasGun incorporates a vastly improved design with progressively-burning propellants that have been proven by independent research to be many times more effective in creating fractures and increasing formation permeability.

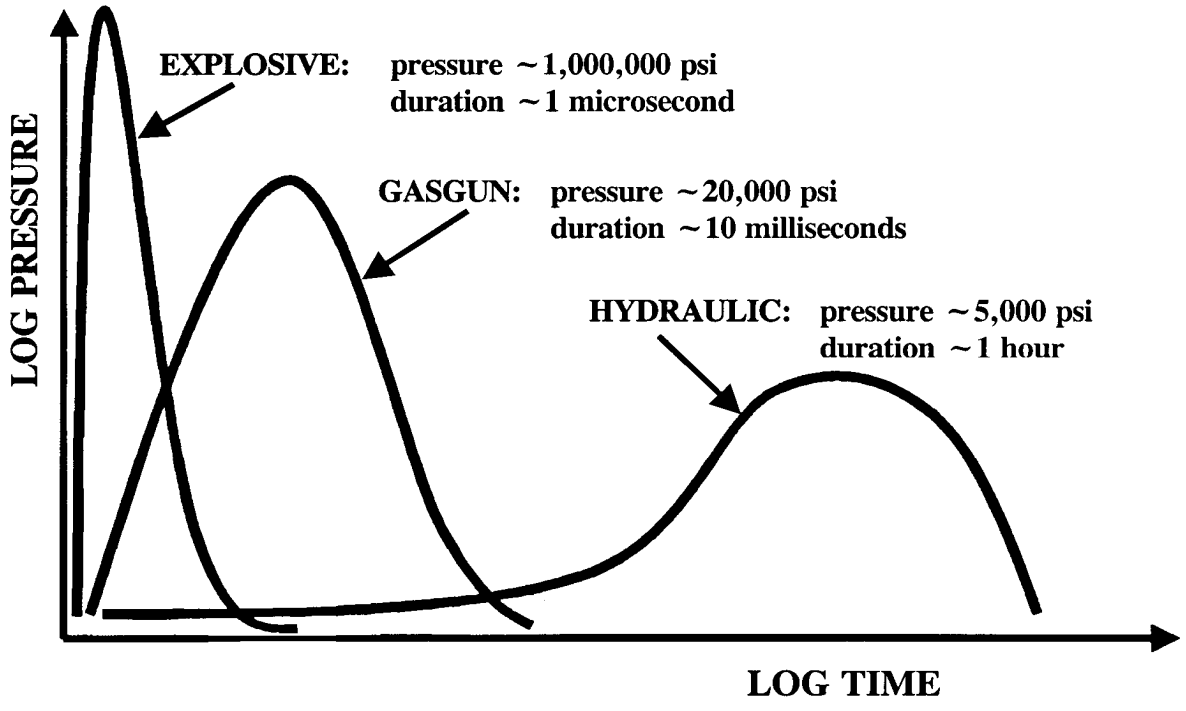
Fielding

The GasGun is simple and easy to field. The propellant is conveyed to the formation in a pressure-tight rubber canister under a fluid column of 300-4000 feet. The fluid column tamps the charge and assures that the energy is restricted to the pay zone. The fluid can be almost anything compatible with the formation; such as fresh water, brine, oil, or solvent.

The tool is usually fielded by wireline. It attaches to the wireline much like a perforating gun, and can be shot with or without a casing collar locator. The tool is ignited while being suspended at the correct depth. Pressure control equipment, such as a lubricator, can be used when needed. Typically little or no cleanup is required, and the well can usually be put back on production immediately after the stimulation.

The GasGun has been engineered in two distinct formulations, one for open-hole and one for cased-hole completions. Perforated casing must be of good quality and have perforation density at least four shots per foot with a 0.5" entry hole diameter or six shots per foot with a 0.375" entry hole to allow sufficient area for the high pressure gas to exit the pipe. The GasGun comes in a standard diameter of 3¼ inches and in lengths of 2, 4, 6, 8 and 10 feet. Producing zones that are more than 10 feet thick are stimulated by connecting multiple tools. Up to 50 feet can be stimulated with a single run.

High explosives, such as nitroglycerine or gelatin, detonate and create a shock wave. Pressures created are extremely high but last only a few microseconds (Figure 1).



Propellants Compared to High Explosives

Figure 1. Pressure-Time Profiles of Three Stimulation Methods

Extensive research has shown that the pressure pulse created by high explosives enlarges the wellbore by crushing and compacting the rock.[1] The enlarged wellbore is left with a zone of residual compressive stress. These residual stresses and compacted rock can actually reduce permeability near the wellbore. Extensive cavings often fill the wellbore with debris that require days, even weeks, to clean up. High explosives are limited to open-hole completions.

The solid propellant used in the GasGun does not actually detonate; it deflagrates. Deflagration is basically a burning process that takes place without any outside source of oxygen. Gas pressures in the range of 20,000 psi are produced that last approximately 10 milliseconds. No shock wave is produced, the rock is split rather than compacted, and multiple fractures are created. The GasGun produces large volumes of gas under high pressure that rapidly extend the fractures into the formation. There are little or no cavings, the integrity of the wellbore is maintained, and cleanup is usually minimal. The well can normally be put back on production immediately. The GasGun can be used in both open hole and perforated pipe completions.

The GasGun Compared to Hydraulic Fracturing

The GasGun will never replace hydraulic fracturing. Large hydraulic fracture treatments can create a fracture hundreds, if not thousands, of feet in length. But many small pay zones in marginal wells cannot justify the expense of these treatments. The GasGun can be a very economical alternative and requires much less equipment for fielding.

Hydraulic fracturing creates a single fracture oriented perpendicular to the least principal *in situ* stress. Unfortunately, the fracture propagates vertically as well as laterally seeking the path of least resistance. Many hydraulic fractures have been known to break out of the producing formation and into aquifers and thief zones. While the fractures produced by the GasGun are more limited in length, gas pressures overpower the *in situ* state of stress, creating multiple radial fractures with minimal vertical growth. Research conducted by Sandia National Laboratories showed the vertical fracture growth to be no more than 2 ft to 5 ft above or below zone.[2] As a result, GasGun fractures are much less likely to break out of the producing zone.

The multiple fractures created by the GasGun may also be much more effective than hydraulic fracturing in naturally-fractured reservoirs. Hydraulic fractures commonly propagate parallel to most of the existing fractures or "with the grain". Multiple fractures may not extend as far, but may link the well to more of the natural fractures (Figure 2).

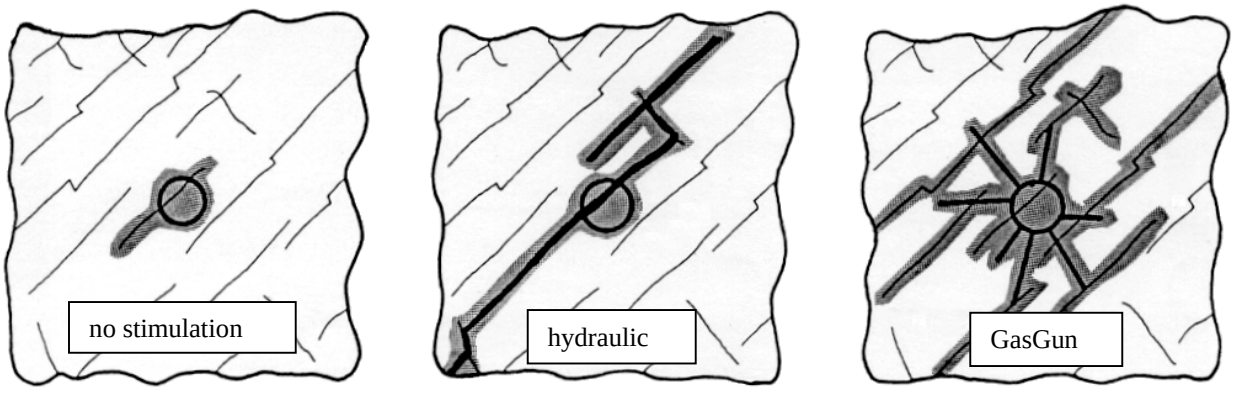


Figure 2. Stimulation of Naturally Fractured Reservoirs

The GasGun Compared to Other Solid Propellant Tools
The GasGun produces several times more gas and energy than most other stimulation tools using solid propellant. (Note: A 3¼" x 10' GasGun tool delivers more than 30,000,000 ft-lb of energy.) GasGun propellant is also significantly more effective in producing fractures since it uses multi-perforated grains that are progressively burning. This means that the rate at which the propellant burns increases with time, producing gas faster as the material is consumed.

The progressive burning is much more effective in controlling peak pressures and advancing the fractures late in the process when crack volumes are the greatest. Independent research bears this out. In a study conducted by Sandia National Laboratories, a multi-perforated propellant was 300 times more effective in enhancing formation permeability than a standard solid propellant in a direct side-by-side comparison.[3]

Stimulating the Arbuckle Dolomite
As of July 2003, over 900 GasGun stimulations had been conducted with 240 of them in Kansas, including 70 in the Arbuckle dolomite. The majority of these wells are in Butler, Stafford, Barton and Ellis counties. One operator has conducted almost half of these Arbuckle stimulations and has developed the following simple procedure: 1) Pull rod and tubing, 2) Select GasGun length to match perforated interval, 3) Shoot GasGun with 1000-2000 feet of fluid tamp, 4) Clear debris and swab, 5) Spot 250 gallons of acid, fill to surface, and let formation take fluid on vacuum, and 6) Rerun rod and tubing and put on pump.

Economic success has been achieved in approximately 75% of the wells in which the operator was willing to share the data. A typical well was making 0-2 BOPD and 0-20 BWPD prior to treatment and 6-8 BOPD and 20-30 BWPD after GasGun stimulation and acid. Production results have shown excellent long-term sustainability.

Lessons Learned
Most of the 900 GasGun stimulations have been conducted in the Appalachian and Illinois basins and in Kansas, Oklahoma, Texas, and Alberta, Canada. Wells have ranged in depth from 200 to 10,000 feet with more than 80% being less than 3,000 feet. Some of the most successful treatments have been in formations that are known to produce large volumes of water when hydraulically fractured. Examples include the Arbuckle formation in Kansas and the Aux Vases, Cypress and Tar Springs formations in the Illinois basin. Successful stimulations have been achieved in many lithologies including sandstone (consolidated and unconsolidated), limestone, dolomite, shale, coal, chert, and chalk.

PTTC Survey of GasGun™ Customers
The GasGun's first major introduction to Kansas operators was at March 2002 Technology Fair, in Wichita, conducted by the North Midcontinent region of the Petroleum Technology Transfer Council. At this meeting, and again at the Independents Day SPE/DOE Improved Oil Recovery Conference in Tulsa a few weeks later, J Integral personnel made presentations describing the technology and its applicability in the Midcontinent. The response from the Kansas industry following these meeting was overwhelming.

In early 2003, the North Midcontinent region of the PTTC conducted a survey of all the operators who had used the GasGun™. Although the response was disappointing (only 15 operators responded), the data was sufficient to project an overview of the performance of the application in Kansas. Operators shared their satisfactions and dissatisfactions with the GasGun™. A summary of this reported information is included in Table A – "Respondents to PTTC Survey" – accessible via the internet at http://www.nmcpttc.org/Case_Studies/Gasgun/table_A.html

In the majority of cases reported, the tool was successful in one or more of the following: 1) increasing oil or gas production, 2) avoiding excessive water production, 3) staying within the desired zone, or, 4) improving the performance of further stimulations. Several operators have utilized the gun numerous

times, and although not all cases were successful, the total effect of all of the operations resulted in a substantial increase in production.

There have been failures. A review of the information provided by the operators, both from the PTTC Kansas survey and customer feedback to J Integral, indicates obvious reasons for the majority of the unsuccessful operations. Primary reasons for unsuccessful results are: 1) attempts to stimulate depleted reservoirs, 2) water present in formation adjacent to perforations, thus unavoidable, 3) well was adequately stimulated previously, 4) poor quality casing, resulting in casing splitting, and 5) poor cement job, resulting in collapsed casing.

To lessen the possibility of failures on GasGun™ jobs, the operator must carefully review the subject well and reservoir. An analysis of the productivity of the well, via production and/or pressure transient tests, should be conducted to determine if 1) the wellbore has a positive skin present and further stimulation should enhance productivity 2) adequate reserves are in place, and, 3) the zone to be treated does not contain a zone of high water saturation that could result in extremely high water production, if treated. In addition, the casing must be of good quality and a bond log has been run to determine the presence and bonding of the cement in the vicinity of the zone to be treated. It is extremely important to verify the competency of the cement behind the casing prior to using the GasGun™.

Confidential Survey of GasGun™ Customers

J Integral has compiled a database, Table B, of all the GasGun applications performed prior to July 2003. In this data, names of operators, lease names, and well locations are confidential. The wells in Table A are duplicated in Table B. Although the individual well data in Table B is not as complete as the data in Table A, it is included to illustrate the range of applications and results of the tool.

Table B may be accessed at: http://www.nmcpttc.org/Case_Studies/Gasgun/table_B.html

References

1) Schmidt, R. A., Boade, R. R., and Bass, R. C., "A New Perspective on Well Shooting - Behavior of Deeply Buried Explosions and Deflagrations," *Journal of Petroleum Technology*, Vol., 33, No. 7, pp. 1305-1311, July 1981.

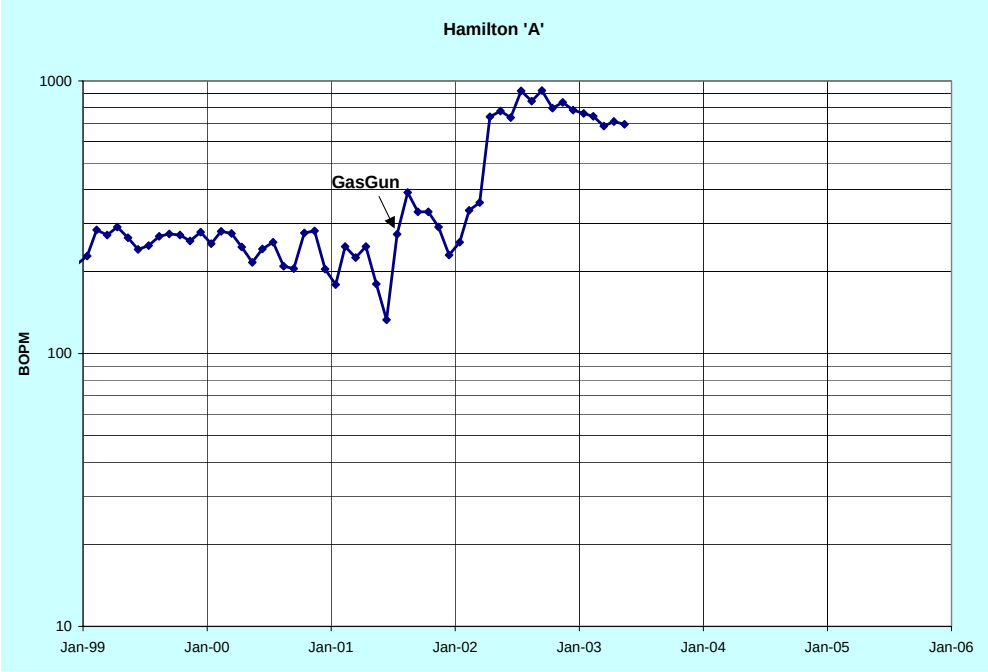
2) Schmidt, R. A., Warpinski, N. R., Finley, S. J., and Shear, R. C., "Multi-Frac Test Series Final Report," Sandia Laboratories Report, SAND81-1239, Albuquerque, New Mexico, November 1981.

3) Schmidt, R. A., Warpinski, N. R., and Cooper, P. W., "*In Situ* Evaluation of Several Tailored-Pulse Well-Shooting Concepts," Proceedings of 1980 SPE/DOE Symposium on Unconventional Gas Recovery, Pittsburgh, Pennsylvania, *SPE 8934*, May 1980.

Vess Oil Corp.; Hamilton 'A' #4
Arbuckle
Butler County, Kansas

This Arbuckle well was producing 2 to 3 BOPD with 12 BWPD prior to treatment in May, 2002. After shooting the GasGun™ the production increased to 16 BOPD with 215 BWPD, with no other treatment. Currently (July 2003), the well is producing 18 BOPD and 272 BWPD and is not pumped off. Since the GasGun application, the well has produced 10,900 barrels of incremental oil.

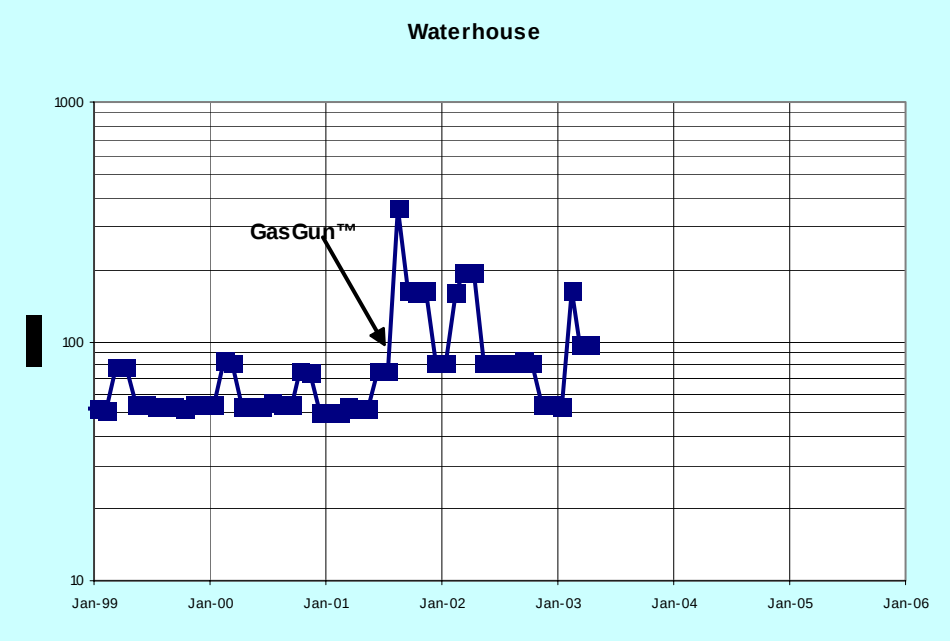
Four other wells on the lease produce a total of 9 BOPD.



Vess Oil Corp. Waterhouse #1
Mississippian Limestone
Hodgeman County, Kansas

The Waterhouse #1 was shot with the GasGun™ in August 2001, utilizing a six-foot gun in the open-hole at a depth of 4274'-80'. The well was then treated with 110 gallons of carbon disulfide and 750 gallons of 10% acid. Prior to the application, the well was producing 1.5 BOPD and 20 BWPD. Afterwards, the production increased to 15-17 BOPD and 80-100 BWPD.

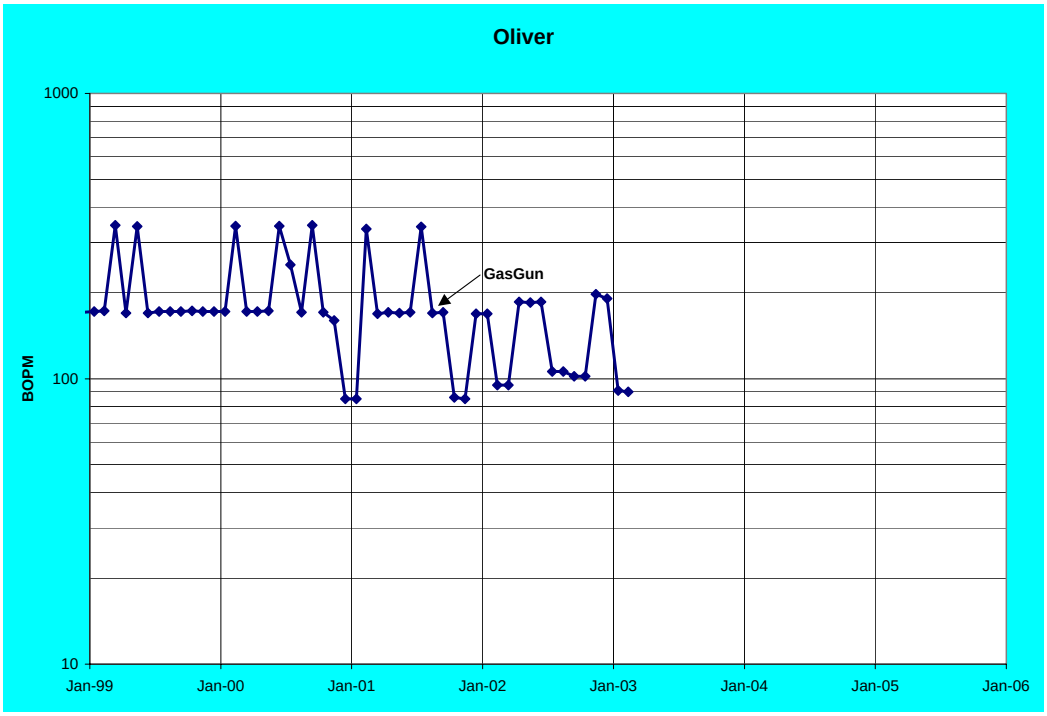
During the two years prior to the treatment, the well averaged less than 60 BO/month, during the first twenty months following the treatment, the well has produced over 120 BO/month.



Vess Oil Corp.; Oliver #4
Mississippian Limestone
Pawnee County, Kansas

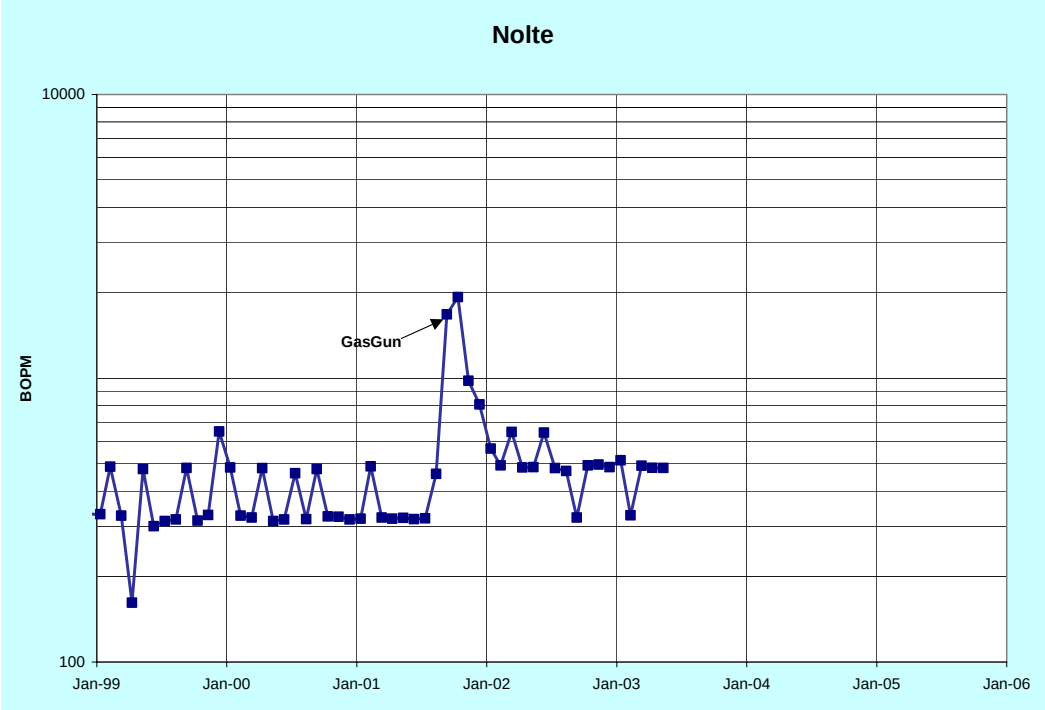
After shooting with GasGun™, and treating with carbon disulfide and acid, operator experienced no change in oil or water production. The well is probably situated in a nearly depleted portion of the reservoir.

Single producing well on lease.



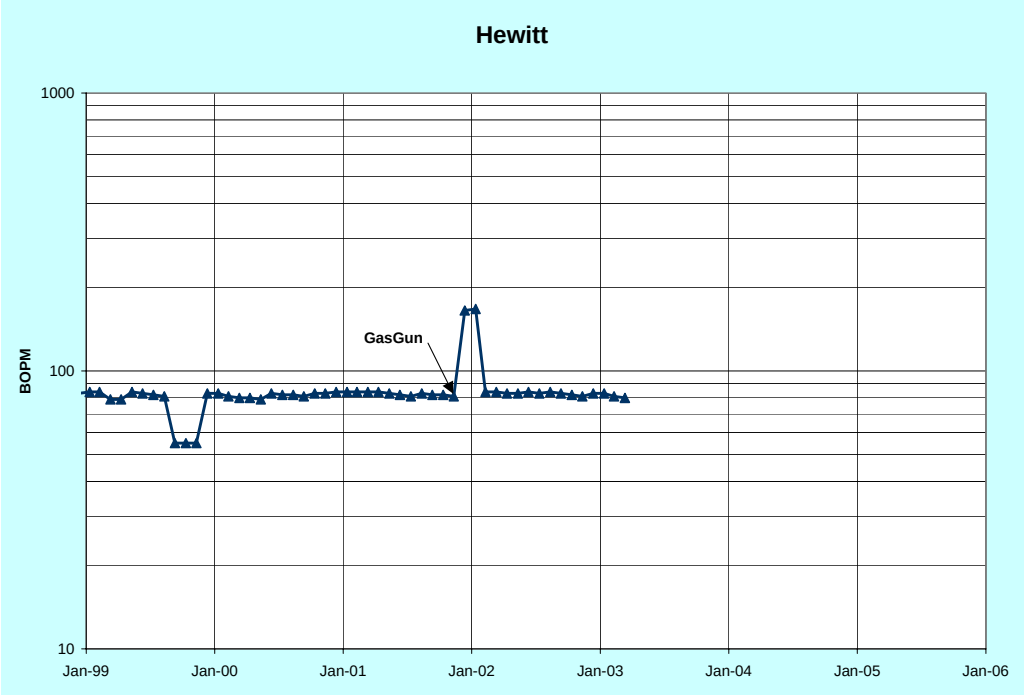
Vess Oil Corp.; John Nolte #2
Arbuckle and Lansing-KansasCity D, F, I, J & K zones
Stafford County, Kansas

Arbuckle was shot with a six-foot gun in cased hole. Zone was treated with 110 gallons of carbon disulfide and 750 gallons of acid. Immediate production was only 1 BOPD with 10 BWPD, but gradually increased to over 20 BOPD. The lease contains four other wells.



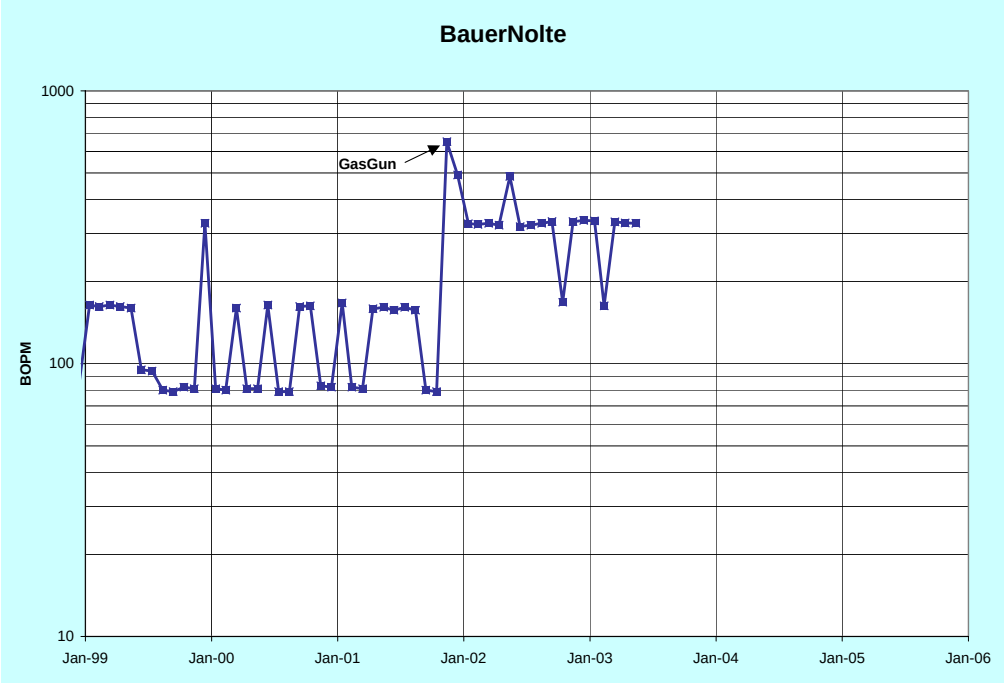
Vess Oil Corp.; Hewitt #2
Arbuckle
Stafford County, Kansas

Very insignificant, short-lived, increase in performance. Well is producing at same rate as before treatment – probably a nearly depleted reservoir.



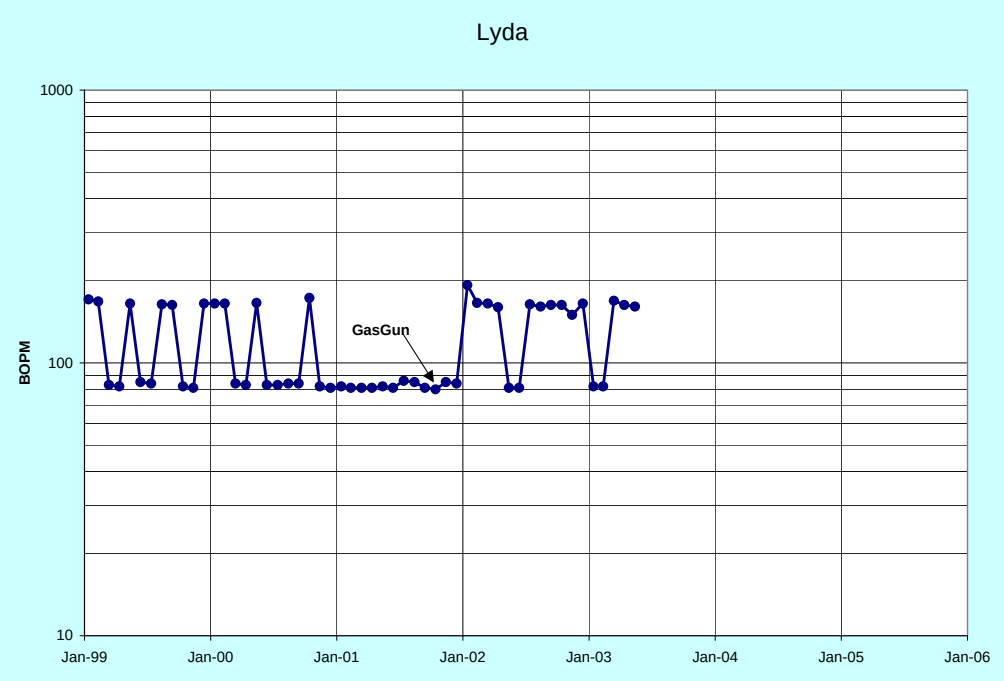
Vess Oil Corp.; Bauer-Nolte #4
Arbuckle and Lansing-Kansas City F & J zones
Stafford County, Kansas

GasGun™ was shot in Arbuckle, commingled with LKC. According to operator, most of the increase in oil is from the LKC. Since shooting with GasGun, the lease has produced an incremental 2,140 barrels of oil. Three producing wells on lease.



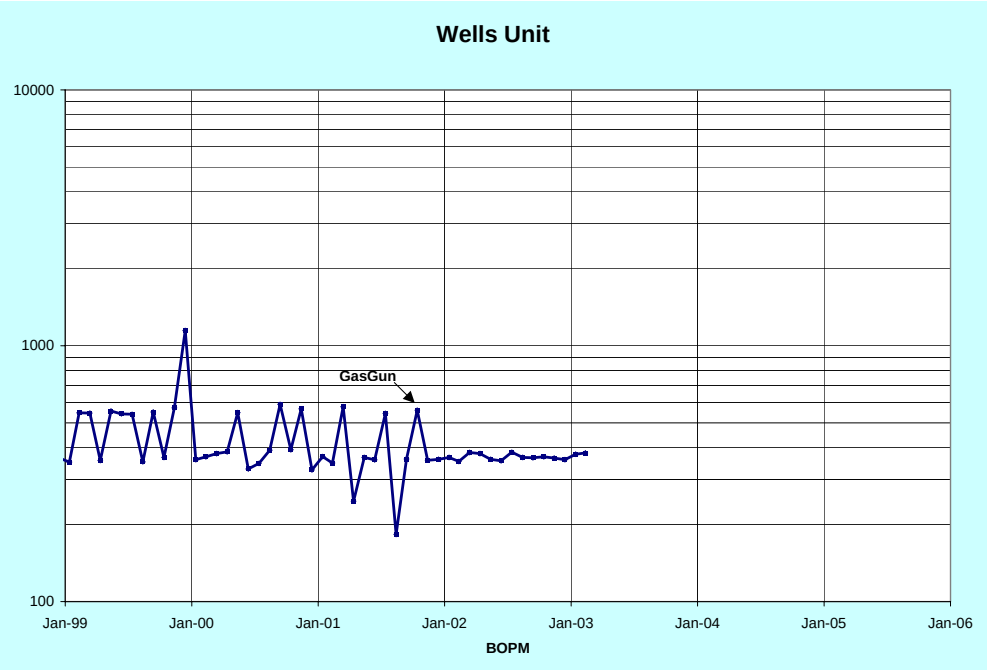
Vess Oil Corp.; Lyda #2
Arbuckle
Barton County, Kansas

Rate prior to GasGun™ and acid treatment was 3 BOPD and 11 BWPD. Three months after treatment the rate was stable at 5 BOPD with 29 BWPD. A six-foot gun was shot through perforations. Through July 2003, the well has produced an incremental 1250 barrels of oil above the trend existing prior to the GasGun stimulation. A single well lease.



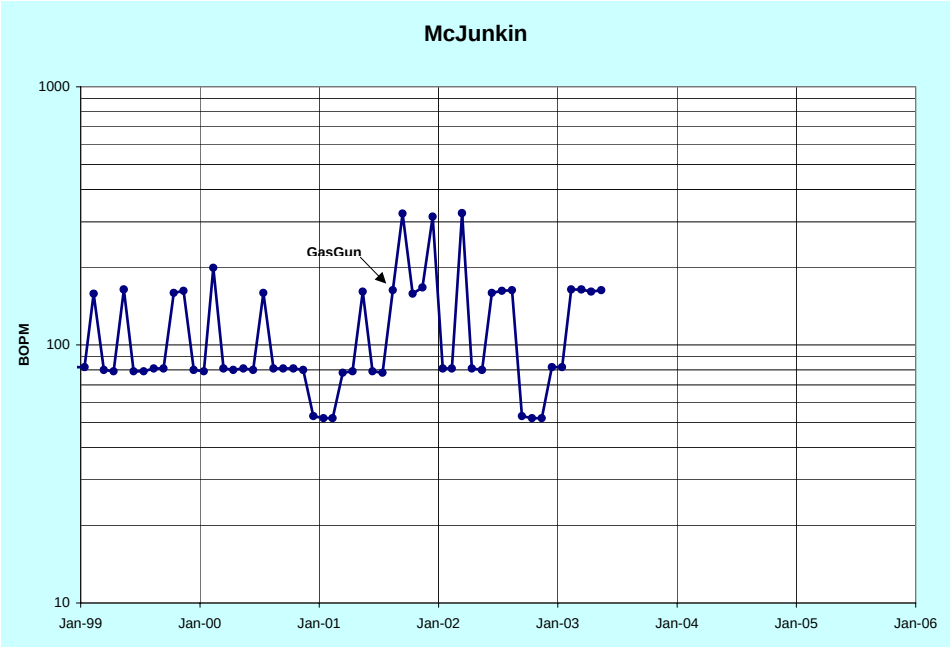
Vess Oil Corp.; Wells Unit #29-3
Mississippian Limestone
Rush County, Kansas

A six-foot gun was fired through perforations, then acidized with 1000 gallons of acid. After one hour only a trace of oil was recovered. Lack of significant production increase may be due to depletion.



Vess Oil Corp.; McJunkin #1
Mississippian Limestone
Rush County, Kansas

A four-foot GasGun™ was shot in the open-hole. After treating with carbon disulfide and 750 gallons of acid, well increased from 2 BOPD and 26 BWPD, to 4 BOPD and 32 BWPD. Two producing wells are on the lease.



Vess Oil Corp.; Ryan 'P' #1
Mississippian Limestone
Rush County, Kansas

A six-foot GasGun™ was shot through Mississippian perfs, and treated with carbon disulfide and 750 gallons of acid. Prior rate of 2 BOPD and 40 BWPD was increased to 5 BOPD and 75 BWPD. Production has been stable for two years, resulting in an incremental 1125 barrels of oil, through July 2003. A single well lease.

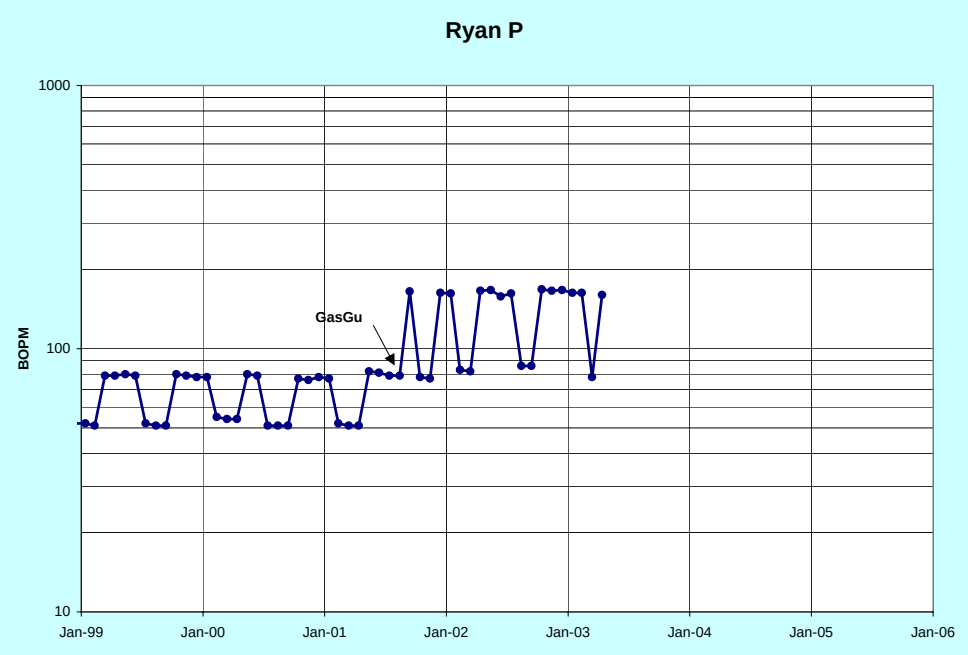


TABLE A RESPONDENTS TO PTTC SURVEY

								Rate Prior				Rate After			
Well	County	Date	Length of GasGun	Depth to Top	Cased or OH?	Casing Size	Formation	BOPD	Rate MCFD	Prior BWPD	Date	BOPD	MCFD	BWPD	Notes
VESS OIL CO.															
Paulson A #121	Butler	12/31/2001	10'	2377	OH		Arbuckle	2		50	August-03	2		10	Tight, spotted acid, no help, shot Gas Gun, spotted 250 gal. acid
Lyda #2	Barton	9/17/2001	6	3433	Cased		Arbuckle	3		11	December-02	5		29	
Wells Unit 29-3	Rush	10/1/2001	6	4364	Cased		Mississippian	2		90	One hour	Trace		16	Sptd. Cbn. disul., 1000 gal. 10% acid
Yeage A #30	Riley	11/7/2001	6	1764	Cased		Hunton	4		20	Immediately	8		40	FL @ 300'; Swbd down; 110 gal carb. disul.
											July-03	4		30	
Porter D 92	Butler	10/11/2001	2	2456	OH		Arbuckle	1		150	Immediately	8		140	Sptd. 350 gal acid
Porter D 87	Butler	7/1/2001	4		OH		Arbuckle	2		16	Immediately	3		9	Attempted acid in 1999; 2500psi, wouldn't breakdown
											July-01	15		85	After 500 gal acid
											July-03	12		102	Increased pump speed
Bauer-Nolte #4	Stafford	11/13/2001	6	3502	Cased		Arbuckle								Opened Arbuckle; L-KC F & J; most oil from L-KC
Hewitt #2	Stafford	11/8/2001	8	3447	OH		Arbuckle								No change in performance
Ryan #1"P"	Rush	9/24/2001	6	4392	Cased		Mississippian	2		40	July-03	5		75	Pf 4392-94, 6spf; 110 gal. Crbn disulf., 750 gal. Acid
Nolte, John #2	Stafford	10/4/2001	6	3520	Cased		Arbuckle	3 to4			Immediately	1		10	110 gas carb.disul.; 750 gal. acid; Arbuckle, L-KC D, F, I, J & K
											increased to	20			
											July-03	2			
Dixon #3		9/11/2001	6	4356	Cased		Mississippian								Job failed
Waterhouse #1	Hodgeman	8/21/2001	6	4274	OH		Mississippian	1.5		9		15		126	110 gal. Cbn. disul.; 750 gal. 10% acid
Oliver #4	Pawnee	8/16/2001	6	4319	OH		Mississippian	6		40	July-03	6		40	Carbon disulfide and acid;
McJunkin #1	Rush	8/23/2001	4	4413	OH		Mississippian	2		26	July-03	4		32	110 gal Carb. disul., 750 gal acid
Pierpoint "A" #118	Butler	12/13/2001	4	2392	Cased		Arbuckle	2		14					No change in production
Wilson "A" #410	Butler	12/13/2001	10	2398	Cased		Arbuckle	0.1 Bbl/hour							
Paulson A #129	Butler	12/13/2001	4	2364	OH		Arbuckle	2		4	January-00	2		70	Tight, spotted 250 gal. acid, 5 oil & 50 water just after job
Starky "A" #24	Butler	4/15/2003	2	2529	Cased	5 1/2	Arbuckle	1		9					Pf 6 spf
"	Butler	"	4	2538	Cased		Arbuckle	2		20	Immediately	4		50	Currently, 3 oil, 26 wtr.
Ahlf #1	Kingman	5/16/2003	6	4372	Cased	4.5	Mississippian	2		20					Pf 4 spf; no change in performance
Enyeart "B" #110	Butler	6/2/2003	10	2429	OH	5.5	Arbuckle	2.7		5	June-03	60		110	150 gal acid; well was previously untreated
											July-03	38		128	
Augusta Tract Unit 2-10	Butler	6/12/2003	4	2564	Cased	5.5	Arbuckle								Job unsuccessful; GasGun fired improperly?
Wilson "A" #410	Butler	5/7/2002	10	2398	Cased		Arbuckle	0.5		5	July-03	3.5		47	Sqzd. Csg. Leak; shot gas gun
Green-Trapshooter R #1	Butler	5/9/2002	8	2366	Cased										No increase in production; P & A
Augusta Unit 1-60	Butler	9/3/2002	2	2570	Cased	5.5	Simpson	Zone not produced			September-02	8		4	Recompletion; GasGun prior to Mini-frac (400# sd @ 2100psi
Chesney "A" #235	Butler	10/17/2002	4	2439	OH		Arbuckle	2		35					
"	Butler	10/17/2002	6	2443	OH		Arbuckle					1		250	
Wilson "A" #426	Butler	10/17/2002	10	2447	OH		Arbuckle	3.5		32	Immediately	45		175	Deepened in Arbuckle; acid
											July-03	10		140	
Abraham Ralston R #31	Butler	12/7/2002	2	2398	Cased	5.5	LKC	1		6	July-03	1		180	Recompletion rom Arbuckle to LKC
Hamilton A	Butler	May-02			Cased		Arbuckle	2 to 3		12	July-02	16		215	
											July-03	18		272	Not pumped off
JIM HAWKINS															
McClure 2-A	Butler	12/21/2001	8	2337	Cased		Arbuckle	5							
Robinson A 16	Butler	4/8/2003	16	2503	Cased		Arbuckle								
Habiger C #1	Rice	1/17/2002	2	3273	OH		Arbuckle								New well
"	Rice	1/15/2003	2	3273	Cased		Arbuckle								
Marsh #2-A	Butler	2/12/2003	4	2451	Cased	4.5	Arbuckle								
McClure #1-A	Butler	8/15/2002	4	2342	Cased		Arbuckle	1		2					Recompletion
West Loomis #1A	Butler	1/8/2002	10	2240	OH	5.5	Arbuckle								Recompletion
McClure #1	Butler	2/25/2002	6	2328	OH		Arbuckle								Recompletion

PINTAIL PETROLEUM															
Watt "A" #1	Harper	10/18/2002	6	4501	Cased		Mississippian		x						Gas well
Turner #2	Harper	12/18/2001	4	4448	Cased		Mississippian								New gas well
Wilson Trust #2	Harper	12/26/2001	4	4420	Cased	4.5	Mississippian								New gas well
BLACK DIAMOND OIL, INC.															
Griffith #6	Rooks			3125	Cased	5.5	L-KC								Casing parted; lost well
ARDC,INC.															
Zenith Unit #33	Stafford			3400	Cased	5.5	L-KC								Treatment allowed for frac job to perform at lower pressure; Operator highly satisfied.
C & J PUMPING, INC.															
Colle, C. J. #1	Reno		4	3662	OH	5.5	Viola						20		After GasGun, 500 gal.of acid and 20 mcf; Operator plans to give larger acid treatment
OIL PROD. INC. OF KANSAS															
Rich "C" #9	Comanche		4	5824	Cased	5.5	Viola								Attempted to penetrate damage and stay in zone; Results were inconclusive
Rich "C" #9	Comanche		4	5838	Cased	5.5	Viola								-ditto-
DOGSTAR PETROLEUM INC.															
Kansas University #2-32	Comanche			5163	Cased	4.5	Ft. Scott								Unsuccessful attempt to reopen zone squeezed to shut off water.
T.D.I. OIL OPERATIONS															
Dreiling "D" #6	Ellis	2000		3300	OH	4.5	Arbuckle					10		150	Considered successful by operator
Dreiling "D" #5	Elis			3300	OH	5.5	Arbuckle								Inconclusive
Company(Confidential)															
Well (Confidential)	Decatur		3	3464	Cased	4.5	L-KC								Attempted to correct unsuccessful completion. Did not help.
RANEY OIL CO., LLC															
Weber	Trego			3950	Cased	5.5	Cherokee								Attempt to increase permeability (production); no increase in fluid in any of the wells. Operator very dissatisfied.
Ott	Ellis			3750	Cased	5.5	L-KC								-ditto-
Leikarn	Ellis			3800	Cased	5.5	Arbuckle								-ditto-
TE-PE OIL & GAS															
Holt #5	Cowley			2300	Cased	5.5	Layton					1		90	Recompletion; did not want to produce a lot of water. Successful; water production low, but zone considered depleted.

CARMEN SCHMITT															
Jones Est. #3	Ness			4340	Cased	5.5	Cherokee								Perf'd after sqz. Used GasGun to penetrate damage. Successful completion. Operator satisfied.
GIANT HOLDING															
Frick #2	Pawnee			2133	Cased	4.5	Herrington / Krider								Unsuccessful. Bad sqz job, no fault of Gas Gun.
KLM															
Harper #2A	Leavenworth	6/30/2003	26	1396	Cased	4.5	McLouth								
Wagner #6A	Leavenworth	6/30/2003	4	1470	Cased	4.5	Mississippian								

TABLE B: APPLICATIONS OF GASGUN™ IN KANSAS

Date	Length (feet)	Open or Cased	Depth	Formation	County	State	Improved?	comments
02/02/01	10	c	4854	Mississippi	Barber	KS	n	Recompletion, drinking fluid, shot w/ 300' fluid, no help.
02/02/01	4	c	4835	Cherokee	Barber	KS		New zone, see above.
10/23/01	4	c	3626	Douglas	Barber	KS	n	No help.
10/24/01	4	c	3626	Douglas	Barber	KS	n	
12/13/01	2	c	4798	Mississippi	Barber	KS	y	
07/17/02	4	c	2808	Tarkio	Barber	KS		
06/09/03	12	c	4820	Mississippi	Barber	KS		
06/18/03	4	c	4478	Mississippi	Barber	KS		
07/28/00	2	o	3287	Arbuckle	Barton	KS	n	28 BOPD prior production dropped to zero.
04/23/01	4	c	3510	Arbuckle	Barton	KS		
09/17/01	6	c	3433	Arbuckle	Barton	KS	y	1 BOPD > 6 BOPD
11/02/01	8	o	3566	Arbuckle	Barton	KS	y	Operator says made more water and oil, but wasn't specific.
11/28/01	6	c	3596	Arbuckle	Barton	KS	w	
03/29/02	8	o	3342	Arbuckle	Barton	KS		
12/17/02	10	c	3367	Arbuckle	Barton	KS		3.3BOPD>?
06/10/03	4	o	3257	Arbuckle	Barton	KS		
06/26/03	6	o	3452	Arbuckle	Barton	KS		
09/27/00	6	c	2467	Simpson	Butler	KS	y	Some help, initally, later fraced at 1000 psi rather than 2200 psi experienced in neighboring well.
10/16/00	8	o	2418	Arbuckle	Butler	KS		Been sitting 1wk, Fluid level @2100'.
10/16/00	8	c	2478	Arbuckle	Butler	KS		New well, lost 100' of 5/16" wireline.
10/19/00	8	o	2394	Arbuckle	Butler	KS	y	One of these three Arbuckle wells, 7 BOPD, 20 BWPD, holding much better than when acidized only, acidized later at lower pressure.
04/17/01	6	o	2421	Arbuckle	Butler	KS	y	Cased hole gun shot in open hole, shot 1' off bottom, wireline stuck, cut wire 10' from tool ($2K-$3K), testing for large field, previous results good, acid jobs of 100 and 300 gallons, went on vacuum and did not produce water
04/18/01	10	o	2384	Arbuckle	Butler	KS	y	On 8/3/01 report, 3 success, 8.7>30 BOPD, one went to water, 2 still unknown but not water.
04/18/01	6	c	2360	Arbuckle	Butler	KS	y	
04/18/01	4	c	2447	Arbuckle	Butler	KS	n	
04/21/01	6	c	2341	Arbuckle	Butler	KS	y	Heard from Log Tech that one of these wells later came in at 12 BOPD and is holding at 12 BOPD.
04/21/01	10	o	2369	Arbuckle	Butler	KS		
10/11/01	2	o	2456	Arbuckle	Butler	KS		
12/13/01	10	o	2377	Arbuckle	Butler	KS	y	2 BOPD, 14 BWPD after gun 6-8 BOPD & 20BWPD.
12/13/01	4	o	2364	Arbuckle	Butler	KS	y	2 BOPD, 20 BWPD after gun 6-8 BOPD & 30 BWPD.
12/13/01	10	c	2398	Arbuckle	Butler	KS	y	Making 6 BOPD but now getting chunks from previous polymer treatment, needs to do fair amount of rework to well.
12/13/01	4	c	2392	Arbuckle	Butler	KS	w	3 BOPD, 14 BWPD well broke into "lots" of water.
12/21/01	8	c	2337	Arbuckle	Butler	KS	y	Log Tech says 25 BOPD levelling at 15.
01/08/02	10	o	2240	Arbuckle	Butler	KS		
01/03/02	4	c	2513	Mississippi	Butler	KS	y	1 BOPD > 2.8 BOPD, increased water by greater factor but not a problem for customer.
02/25/02	6	o	2328	Arbuckle	Butler	KS		
05/07/02	10	c	2398	Arbuckle	Butler	KS	y	Well had polymer treatment in 80's to shut off water but shut off production too, came in at 6 BOPD and 30 BWPD after gun, customer happy.
06/07/02	8	c	2366	Arbuckle	Butler	KS	y	Only 1/2 BOPD better than before, is going to P&A.
08/05/02	4	o	2617	Arbuckle	Butler	KS	n	Arbuckle was producing water, shut off with squeeze, shot gun and got nothing.
08/15/02	4	c	2342	Arbuckle	Butler	KS	y	1> 7 BOPD after acid
09/03/02	2	c	2570	Simpson	Butler	KS	y	Can't normally frac or brings in water, shot gun but no initial improvement, was later able to do small frac and got 7 BOPD & 4 BWPD, customer happy.
10/17/02	10	o	2447	Arbuckle	Butler	KS	y	3>28BOPD, 60>171BWPD.
10/17/02	10	o	2439	Arbuckle	Butler	KS		2>? BOPD, 35>? BWPD.
12/17/02	2	c	2398	Arbuckle	Butler	KS	n	1BOPD>?, 6BWPD>now just making all water.
02/12/03	4	c	2451	Arbuckle	Butler	KS		
04/08/03	16	c	2503	Arbuckle	Butler	KS		
04/15/03	4	c	2538	Arbuckle	Butler	KS	y	2BOPD>4BOPD with Acid treatment.
04/15/03	2	c	2529	Arbuckle	Butler	KS	y	2BOPD>4BOPD with Acid treatment.
05/29/03	2	c	2472	Arbuckle	Butler	KS		Cased hole gun shot in open hole.
05/29/03	6	c	2445		Butler	KS		
06/02/03	10	o	2429	Arbuckle	Butler	KS		
06/12/03	4	c	2564	Arbuckle	Butler	KS		
07/16/03	10	o	2447.5	Arbuckle	Butler	KS		
12/03/01	10	c	1972	Mississippi	Chautauqua	KS	y	Log Tech says it increased and was acidized.

12/03/01	6	c	1659	Mulky	Chautauqua	KS	y	Coal, gas increased enough to run pumps.
01/15/02	6	c	1588	Mulky	Chautauqua	KS		Left 600' of line in hole, 1/23 fished line, cable head and top of tool came out inverted, obstruction at 800'.
01/15/02	6	c	1706	Mulky	Chautauqua	KS		Left 1300' of line in hole, fished out and cleared gun to bottom.
04/11/02	4	c	1914	Riverton Coal	Chautauqua	KS	y	Perforated 8 SPF > making more gas.
04/11/02	6	c	1972	Mississippi	Chautauqua	KS	y	Perforated 8 SPF > making more gas.
04/11/02	6	c	2011	Mississippi	Chautauqua	KS		
04/11/02	6	o	1802	Mississippi	Chautauqua	KS		
01/05/01	10	c	1477	Bartellsville	Coffey	KS		New well, making lots of water on 1/18, will continue to pump.
09/14/00	8	c	5035	Pawnee	Comanche	KS	y	5 1/2" Casing, 70 > 140 MCF/D 0? > 3 BOPD, improving.
09/14/00	4	c	5143	Mississippi	Comanche	KS	y	5 1/2" Casing, 70 > 140 MCF/D 0? > 3 BOPD, improving .
09/27/00	8	c	4974	Altamont	Comanche	KS		Lost 650' of line.
09/27/00	8	c	5024	Pawnee	Comanche	KS		
09/25/00	6	c	5070	Mississippi	Comanche	KS		
10/04/00	8	c	5020		Comanche	KS		
10/04/00	6	c	5130		Comanche	KS		
11/09/00	6	c	5342	Mississippi	Comanche	KS		
02/14/01	6	c	5080	Mississippi	Comanche	KS		New well, tight hole well.
04/10/01	6	c	5163	Ft. Scott	Comanche	KS		4 shots/ft, acidized, squeezed, 6 shots/ft, then GasGun.
04/12/01	6	c	5163	Ft. Scott	Comanche	KS		Second shot in exact same spot.
01/28/02	6	c	5154		Comanche	KS		
09/17/02	4	c	3538	Stotler Lime	Comanche	KS		
01/09/03	4	c	5821	Viola	Comanche	KS		
01/30/03	4	c	5838	Viola	Comanche	KS		
01/30/03	4	c	5824	Viola	Comanche	KS		
01/30/03	6	c	n/a	Mississippi	Comanche	KS		
03/10/03	12	c	5330	Mississippi	Comanche	KS		
05/12/03	4	c	4980	Mississippi	Comanche	KS		Somewhat stuck, cleared 20' wire and later rubber with junk basket, used as prefrac, went to water, squeeze.
05/12/03	10	c	4948	Mississippi	Comanche	KS		see above
05/13/03	8	c	5592		Comanche	KS		Bailed down to 2592' of fluid.
10/30/01	4	c	2983	Mississippi	Cowley	KS	y	#NAME?
02/12/02	4	c	3342		Cowley	KS		1.67 BOPD>
04/01/02	4	c	2358	Layton	Cowley	KS		
04/04/02	4	c	3062		Cowley	KS		Report of rubber getting in pump
05/06/02	10	c	3090	Mississippi	Cowley	KS		Pulling out rubber with swab, marble size up to a 3.5" - 11" piece
10/01/02	4	c	3464		Decatur	KS		
11/06/00	4	o	3400	Arbuckle	Ellis	KS	n	No help, been shut down for 15 years, acidized after shot and brought in the ocean.
04/01/02	4	c	3600	Kansas City	Ellis	KS	y	Brought back entire canister, acid job went with 850 psi rather than usual 1600, 3 BOPD > 14 BOPD for month steadied at 8 BOPD.
07/23/02	6	c	3279	Kansas City	Ellis	KS		
08/01/02	4	o	3387	Arbuckle	Ellis	KS		
10/09/02	8	c	3640	Arbuckle	Ellis	KS		
10/17/02	4	c	3388		Ellis	KS		
10/17/02	4	c	3582	Arbuckle	Ellis	KS		
10/16/02	4	c	3569		Ellis	KS		New well
07/08/03	2	c	3412	Arbuckle	Ellis	KS		Shot in open hole
07/08/03	2	c	3396	Arbuckle	Ellis	KS		Shot in open hole
04/19/02	4	o	3295	Arbuckle	Ellsworth	KS		
05/29/02	8	c	3390		Ellsworth	KS		Existing production 1 BOPD
08/19/02	6	o	3234	Arbuckle	Ellsworth	KS		
02/25/02	4	c	4250	Mississippi	Finney	KS		
05/06/02	10	c	650		Franklin	KS		1/4 BOPD before shot, added section of tubing to bottom of gun and ran in easily, lost 250ft of line and had to fish.
05/22/02	4	c	3662	Regan Sand	Graham	KS		
11/11/02	4	c	3578		Graham	KS		
02/02/01	6	c	4373	Mississippi	Harper	KS		New completion.
12/18/01	4	c	4448	Mississippi	Harper	KS	y	New gas well, 4.5" casing, 0.48" @6spf, acidized and wants to try to put on prod. w/out frac., initial prod. Is 340 MCF in 4 hours.
12/26/01	4	c	4420	Mississippi	Harper	KS	y	New gas well, 4.5" casing, 0.48" @6spf, acidized and fraced, treating pressure normaly 1,900psi, after GasGun treating pressure 1,000psi.
10/18/02	6	c	4501	Mississippi	Harper	KS		Gas well
11/07/02	4	o	4320		Harper	KS		
06/17/03	6	c	4434	Mississippi	Harper	KS		
06/23/03	6	c	4417	Mississippi	Harper	KS		
11/28/01	4	c	2912	Mississippi	Harvey	KS	n	Previously had small show of gas that could light on fire, hole went dry after shot.
11/27/02	8	c	3236	Mississippi	Harvey	KS		Cased hole guns shot in open hole

08/21/01	6	c	4274	Mississippi	Hodgeman	KS	y	Cased hole gun shot in open hole, 1.67 > 16.7 BOPD and 20 > 85 BWPD for 2 weeks.
10/16/01	8	c	4422	Mississippi	Hodgeman	KS	n	No help.
02/20/02	4	c	4053	Mississippi	Kingman	KS		Casing split, 3718-3745.
03/13/02	6	c	4125	Mississippi	Kingman	KS	n	Shot in open hole, had to drop fluid on top to get going, 7' of open hole, 3900' fluid, dragged and broke off 15' of line 500' unchanged - disappointed.
05/16/03	6	c	4372	Mississippi	Kingman	KS	y	Gas well went from 30 MCF > 68 MCF
05/21/03	4	c	1714	Indian Cave	Kingman	KS		
01/14/03	6	c	1431	Burgess	Leavenworth	KS		
06/30/03	4	c	1470	Mississippi	Leavenworth	KS		
06/30/03	26	c	1396	McLouth	Leavenworth	KS		
07/22/03	10	c	n/a	McLouth	Leavenworth	KS		
07/22/03	6	c	"	McLouth	Leavenworth	KS		
05/21/02	8	c	2962	Mississippi	McPherson	KS		
02/12/02	10	c	5796	Chester	Meade	KS		
08/30/02	4	c	1306	coal	Montgomery	KS	y	Increase of only 1-2 MCFPD and no increase in water
08/30/02	4	c	1463	coal	Montgomery	KS	n	No help
06/04/02	4	c	1044	Riverton Coal	Neosho	KS	n	Had been fraced several times, customer said not very good candidate, plan to do more.
11/09/01	2	c	4305		Ness	KS		
12/10/01	4	c	4248	Cherokee	Ness	KS		
04/29/02	10	o	3674	Arbuckle	Norton	KS	y	3.8 > 6.8 BOPD (Log Tech says it was 1.8 originally)
03/13/01	8	c	1390	Burgess	Osage	KS		Log Tech does not hold much hope for this well.I205
03/13/01	8	c	5430	Mississippi	Osage	KS		
02/19/02	10	c	3208		Osborne	KS		
06/13/01	4	o	4355	Mississippi	Pawnee	KS	y	Old well, 1.67 BOPD > 2.42, is going back to treat with carbon disulfide and acid like 4 wells done after this one.
08/16/01	6	o	4319	Mississippi	Pawnee	KS		These three wells are in chert.
09/11/01	6	c	4356	Mississippi	Pawnee	KS		
12/28/01	10	c	2446		Pawnee	KS	n	New well, Log Tech and customer feel there wasn't anything there, acid treatment also didn't help.
12/28/01	8	c	2254		Pawnee	KS	n	-ditto-
04/22/02	6	c	2133	Krider	Pawnee	KS		
06/05/02	10	o	4095	Conglomerate	Pawnee	KS		
07/03/02	6	c	3862	Simpson	Pawnee	KS		
07/23/02	6	c	1911		Pawnee	KS		
09/17/01	4	c	4108	Cherokee	Pratt	KS		"Went on vacuum"
04/03/02	4	c	3662	Viola	Reno	KS		Lost 6' line.
09/28/01	4	c	2986	Stranger Sand	Rice	KS		
06/11/02	4	o	3218		Rice	KS		
06/21/02	4	c	3275	Misener	Rice	KS		Cased hole gun shot in open hole, used pre-frac.
09/06/02	4	c	3302		Rice	KS		
11/13/02	4	c	3215	Conglomerate	Rice	KS		
01/17/03	2	c	3273	Arbuckle	Rice	KS		Cased hole gun shot in open hole.
06/16/03	4	o	3255	Arbuckle	Rice	KS		
11/07/01	6	c	1764	Hunton	Riley	KS	y	Doubled production.
12/02/02	6	c	3051	Kansas City	Rooks	KS		Lost 400' of line in hole.
08/23/01	4	o	4413	Mississippi	Rush	KS	y	Wells shares storage tank, total volume from 30 > 80, estimate 10 BOPD increase from GasGun.
09/24/01	6	c	4392	Mississippi	Rush	KS		Shot 2' of GasGun in cased hole and remaining 4 " in open hole.
10/01/01	6	c	4364	Mississippi	Rush	KS		
01/23/01	4	c	2393	Tarkio	Russell	KS	y	Lost cable head, recompletion, shot above bridge plug, 0>5 BOPD and lots of gas (can't sell and is gas locking), customer pleased, still at 5 BOPD after 8 months.I236
01/23/01	4	c	2385	Tarkio	Russell	KS	y	see above
11/30/01	6	c	3214	Arbuckle	Russell	KS		
01/24/02	2	c	3321	Arbuckle	Russell	KS		2BOPD>?
02/07/02	2	c	2839	Kansas City	Russell	KS		
02/07/02	4	c	2742	Kansas City	Russell	KS		
04/11/02	4	c	2955	Topeka	Russell	KS	y	
04/11/02	4	c	2944	Topeka	Russell	KS	y	Producing 1.5 BOPD before shot > 6 BOPD
05/31/02	2	c	3322	Arbuckle	Russell	KS		
03/13/03	4	o	3990	Mississippi	Sedgwick	KS		
04/10/02	6	c	3399		Seward	KS	y	Mostly water increase, but pleased and will shoot more.
05/07/02	6	c	5714	Chester	Seward	KS		Followed GasGuns with acid frac.
05/07/02	8	c	5700	Chester	Seward	KS		
05/10/02	20	c	5764	Chester	Seward	KS		Followed GasGuns with acid frac.
08/14/02	4	c	2029		Sherman	KS		New well.

10/04/01	6	c	3520	Arbuckle	Stafford	KS	n	Well went to water, operator not unhappy.
11/08/01	8	o	3447	Arbuckle	Stafford	KS	y	1 BOPD increase over previous production.
11/13/01	6	c	3502	Arbuckle	Stafford	KS	y	1 BOPD increase over previous production.
01/23/02	10	c	3360	Arbuckle	Stafford	KS		Lost 250' line, 5BOPD>?
04/01/02	10	c	3352	Arbuckle	Stafford	KS		
07/01/02	2	c	3479	Kansas City	Stafford	KS		
08/19/02	4	c	3739	Arbuckle	Stafford	KS		
11/14/02	8	o	3265	Arbuckle	Stafford	KS		
12/12/01	4	c	6242		Stevens	KS		
12/12/01	8	c	6228		Stevens	KS		Got stuck, suspect casing damage?
12/27/02	16	c	5495	Mississippi	Stevens	KS	y	Previous acid job didn't work treating pressure 2000psi after GasGun treating pressure 1000psi.I262
03/13/02	6	c	3511		Sumner	KS		
06/24/02	6	c	3340	Mississippi	Sumner	KS		
08/08/02	2	c	n/a		Sumner	KS		
06/18/03	4	c	2986	Stallnaker	Sumner	KS		
03/05/02	10	c	3809	Marmiton	Trego	KS		
07/09/02	6	c	4128	Cherokee	Trego	KS		
07/09/02	2	c	4148	Cherokee	Trego	KS		
05/07/02	16	c	946		Wallace	KS		
06/25/02	6	o	3255	Arbuckle		KS		30 BWPD, 1 BOPD>?
10/30/02	6	c	n/a			KS		Cased hole gun shot in open hole, 2>? BOPD.I35