ECCENTRIC-VEIN GAS SEPARATION

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HISTORY

For decades producers have fought the problem of lost pump efficiency due to downhole gas interference. Downhole pumps can loose 20% to 100% of published efficiencies due to free gas problems. This is especially true when the pump is placed above the perforations. To correct this problem producers have tried a variety of remedies. Some of the remedies, such as knockers, spring-loaded balls and backpressure valves, do not directly attack the problem. Although these tools have proven to be helpful in pump operations they do not solve the root problem. Gas interference in reciprocating pumps causes lost production, premature pump failure, rod parts and excessive wear on surface equipment. Other types of lift equipment are also affected by gas interference. Progressive cavity pumps require liquid to lubricate and cool the polymer sealing materials. Free gas will greatly decrease the efficiency and life of these pumps. This is also true with submersibles as they require a constant flow of fluids for motor coolant.

The most common downhole separator is made from materials found in pump yards. A joint of pipe is perforated and orange pealed on the bottom. This is attached to the seating nipple or lower barrel coupling and a dip tube is attached to the pump. Gas separation takes place between the dip tube and inside diameter of the perforated sub. This tool is often called a "Poor-Boy" gas separator (Fig 1). The fluid efficiency of this separator is limited to about 50 BPD due to the limited space between the dip tube and outer case. Pressure differentials created by the upstroke of the pump add to the tools inefficiency. On the upstroke a pressure differential is created between the inside of the separator and the casing annulus and fluids flow into the gas separator. Fluids surrounding the separator often contain 75% free gas. Considerable amounts of gas are drawn into the separator and very little separation takes place due to the pressure differential. In a conventional "Poor-Boy", most of the fluid and gas flow occurs on the up stroke and most of the gas discharge occurs on the downstroke creating low efficiency. [FN1,2,3,4,5]

DEVELOPMENT

The eccentric-vein separator is a combination of new technology and proven methods. The Stanley Filter Company has long been involved in downhole gas separation with its line of filters. Over the past ten years filters have been used as an effective means of downhole gas separation, however the surge in the coal-bed-methane industry brought about new problems and a change in thinking.

A customer in the Powder River Basin approached us to design a downhole tool that would filter coal dust and separate gas. We tried a variety of filter medias and configurations with no measure of filtering success. Although the tools demonstrated good gas separations all of the filter medias failed due to the size of the coal fines. To filter the fines we had to use close-knit medias and the volume of fines rapidly packed off the filters.

The packed filters prompted a change in our thinking. After discussions with the manufacturers of rod, submersible and progressive cavity pumps we came to the conclusion that it was best to pump the coal fines to the surface and concentrate on gas separation. We turned our attention to an open weave fiberglass product that we have previously used as an outer case in some of our tubing filters (Fig 2).

We had experimented for several years with eccentric weave in our filter lines. The veins, .04" to .06", are small enough to separate gas, but too large to trap fines. In addition the veins are radial with an eccentric saw tooth pattern. Due to the radial design the veins decrease in size from the outside to inside of the tool (Fig 3). A combination of vein size and the radial saw tooth patterns give the tool its gas separation qualities. Free gas is separated by the outer case of this tool rather than between the outer case and dip tube as in a "Poor Boy". The sizes and quantity of veins, approximately 9 per square inch, maintain good permability as the pressure drop across a 6-foot tool is 1.5 pounds per square inch at 400 barrels per day rate. Due to the eccentric-vein and low pressure drop the tool delivers more fluid and less gas to the pump intake.

The eccentric vein is created when the fiberglass is layered over a mandrel. Each pass is offset from the previous layer and each layer is wound from the opposite direction from the previous pass. This process gives the vein its unique radial saw tooth design. Each vein has multiple sets of overlapping saw teeth (Fig 4). The torturous path increases the ability of the tool to separate free gas from produced fluids. The fiberglass is also resistant to most well bore treatment chemicals and downhole temperatures. To cover a broad range of downhole temperature the separators are offered in two ranges, I80 deg. f and 300 deg. f.

Several styles of separators were designed to accommodate different types of lift equipment. The first one developed was a shroud for submersible pumps in the Powder River Basin. An all fiberglass tool that provides for motor cooling and gas separation (Fig 5). It consists of three chambers: 1 an upper housing that covers the submersible equipment; 2 an intake section of open weave; 3 and lower reservoir section. All three sections are assembled into one unit with a 1-1/2" dip tube estending down from the bottom of the upper section to 6 feet into the lower section. Fluid enters the separator through the open weave section then falls into the reservoir and up the dip tube to the upper section and into the pump intake.

For reciprocating wells a range of separators were designed to accommodate fluid volumes. casing and tubing sizes. (Fig 6) The tubing separator has an inner mandrel of steel with female to male adapters. A spacing of .125" is maintained between the mandrel and outer case to allow for lateral flow inside the separator. The lateral flow aids the separator in maintaining low pressure drop.

A dip tube "Stinger" version was designed for low volume wells (Fig 7) The stinger and adapters are fiberglass. The stingers are available in 1" X 3'. 1-1/4" X 6' and 1-1/2" X 6'.

LAB AND FIELD TESTING OF ECCENTRIC-VEIN

Lab testing was conducted in house and at Stem-Labs of Duncan, Okalahoma. Stem-Labs conducted flow, pressure drop and gas separation test. The separation test was conductcd in a simulated downhole test bed using a 14" GS-3.5 separator. Water and gas was introduced in the test well three feet below the separator. Liquid rates ranged from 20 to 1000 barrels per day and gas rates from 20 to 50 mcfd. Maximum gas rates were 50 mcfd due to the short length ofseparator. At 650 bpd fluid the separator was 98% efficient. (Fig 8) The separator is designed to remove free gas and the size of gas bubbles will affect end results.

Separate flow and pressure drop tests were conducted on the 14" separators and standard length stingers. All ofthe tests indicated high flow rates and low-pressure drops. (Fig 9 & 10)

San Juan Field Test

The nest phase was field-testing in the San Juan Basin. A producer of coal-bed-methane gas agreed to replace I3 "Poor Boys" with tubing style *GS-3.5* eccentric-vein separators. The wells ranged in depth from 1800 to 3200 feet. Fluid production was 20 to 200 bpd with gas rates of300 to 700 mcfd. The test separators were installed above or between two sets of perforations (Fig 11). After six months they reported production increases of up to 57.14% and overall increases in all 13 wells. (Fig 12) The producer is now installing the eccentric-vein as standard operating procedure.

Progressive Cavity Test

Progressive cavity pump test was conducted in the Raton Basin. Before installing -'Eccentric-Vein" separators the well was producing less than 200 bpd fluid and 125 mcfd. Initial test indicated the well should be delivering between 300 and 400 mcfd. They were experiencing gas displacement problems and had tried a variety of remedies over the past two years. Tandem separators were installed below the PC with a mud anchor and dip tube. Production increased to 306 bpd fluid and 346 mcfd. The pump manufacturer reported the pump was at 7506 torque and no measurable gas up the tubing. (Fig 13)

Efficiency Reduction Test

In East Central Oklahoma an efficiency test was conducted by measuring the volume ofgas produced up the tubing before and after installation of an "Eccentric-Vein" separator. After two months they reported 85% to 98% reduction in gas up the tubing. Fluid rates increased by 4.76% to 27.78% and an overall increase in total gas production. (Fig 14)

As of this date over 2900 varying styles of the eccentric-vein separators have been installed. Applications include reciprocating, submersible and progressive cavity pumps. Well depths range from 500 feet to 10.000 feet. Fluid and gas volumes vary from 6 bpd to 1200 bpd and 20 mcf to 1, I00 mcfd.

INSTALLATION

The eccentric-vein tubing separator can be installed in a number of different configurations. The most common installation is to attach the separator to the bottom ofthe seating nipple or lower barrel coupling. A mud anchor is attached to the bottom ofthe separator. The pump should have a dip tube of sufficient length to clear the separator by 6 feet (Fig 15). If the well is deviated we recomtnend installing centralizers above and below the separator.

Installation requires a tubing sub when installing a GS-3.0 separator in 4-1/2" casing with a 2" insert pump with top hold down. (Fig 16) The inside diameter of this tool is 1-3/4" and will not accommodate a 2" insert pump. Install a tubing sub. below the seating nipple. of sufficient length to house the pump. Attach the gas separator just below the tubing sub followed by a closed end mud anchor. A 10-20 *foot* dip tube should be attached to the bottom ofthe pump. It is not recommended in any application to set a pump inside an eccentric vein separator as it could create pressure differential.

Tubing installation is the same for wells with progressive cavity pumps. A dip tube adapter is installed in the top ofthe separator (Fig 17).

Submersible applications require a shroud. A complete shroud is available for submersible applications in the Powder River Basin. The shroud is attached to the tubing string by means ofa split top adapter.

The Stinger is recommend in applications where the pump intake is below the perforations. The Stinger is attached to the standing valve ofthe pump or at the bottom of a dip tube. We do not recommend use ofa mud anchor in this application. (Fig 18).

PROBLEM SOLVING

Will the separator act as a filter and will it plug off are two ofthe most commonly asked questions. The answers are it is not a filter and yes it can plug. An in house flow test was conducted using water at a rate of650 bpd. and 20/40 frac sand. Over 20% of the frac sand penetrated the open weave outer case. Most frac and unconsolidated sands are smaller in size that the veins. If frac sand is a problem we recommend installing filters.

The separator is subject to plugging if submerged in sludge or drilling mud. If these conditions exist we recommend cleaning the well bore before installation. If paraffin breaks out in pumping equipment it will breakout in the separator Additionally low back of frac sands can plug the separator.

Most of the problems encountered with separator plugging can be solved with good well bore maintenance

REFERENCES

1. J.N. McCoy: "Improved Downhole Gas Separation." Southwestern short Course on April 7 & 8 1998.
2. McCoy. J.N. Podio, A.L., Drake. B. and Becker D: "Total Well Management A Methodology for Maximizing Oil Production and Minimizing Operating Cost", Paper presented at the SPE Third Annual Symposium Calgary. Alberta. Canada. May 23, 1995
3. Clegg. J.D.: "Understanding and Combating *Gas* Interference in Pumping Wells," Oil and *Gas* Journal. April 29, 1963
4. Clegg. J.D.: "Gas Interference in rod pumping wells," World Oil. June 1979
5. Clegg. J.D.: "Another look at gas anchors," Proceeding ofthe Southwestern Petroleum Short Course. Texas Tech University. April 1989

Poor-Boy Gas Separator

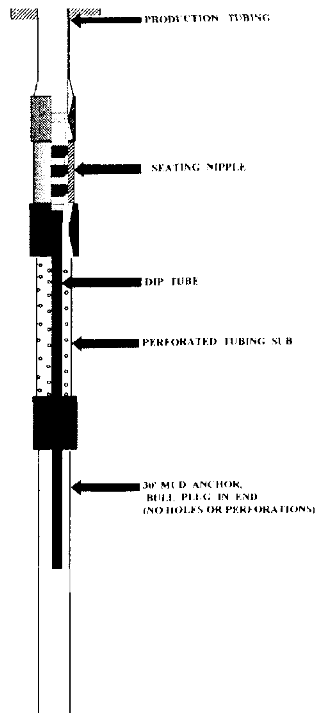

Figure 1

Side View Eccentric-vein Outer Case

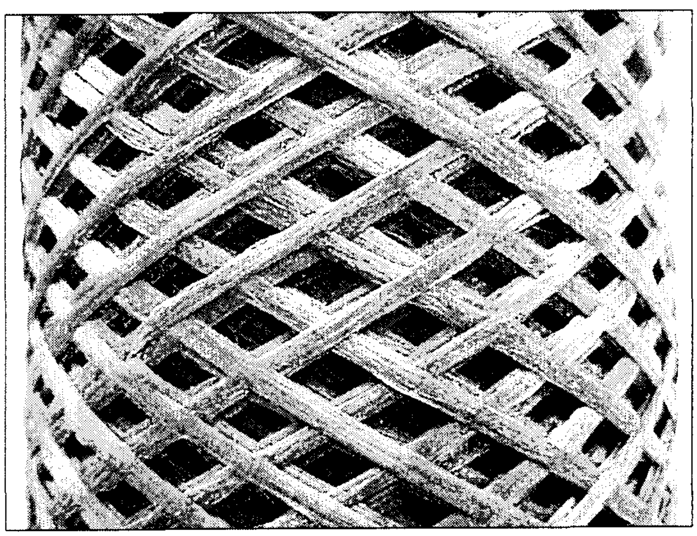

Figure 2

Cross Section Eccentric-vein Outer Case

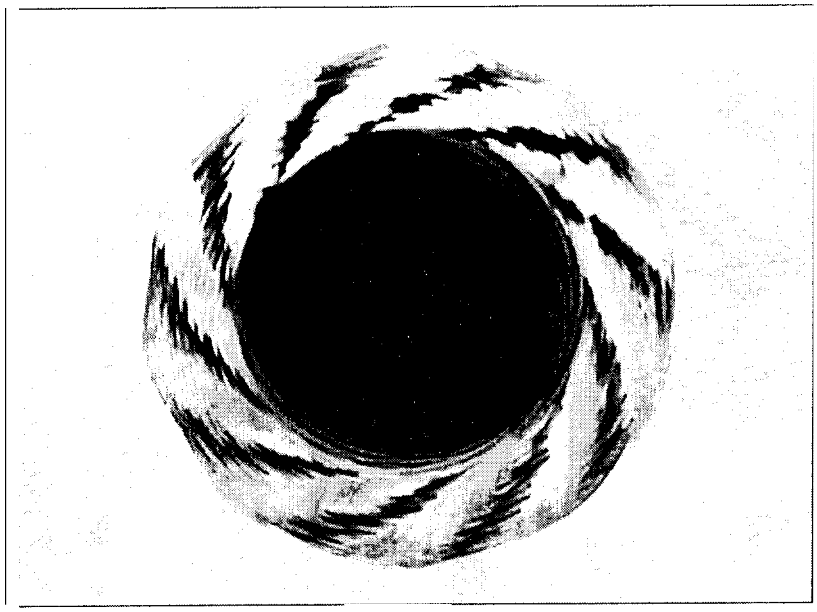

Figure 3

Eccentric-vein Sawtooth Pattern

Figure **4**

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Gas Separator Shroud Application for Submersible Pumps

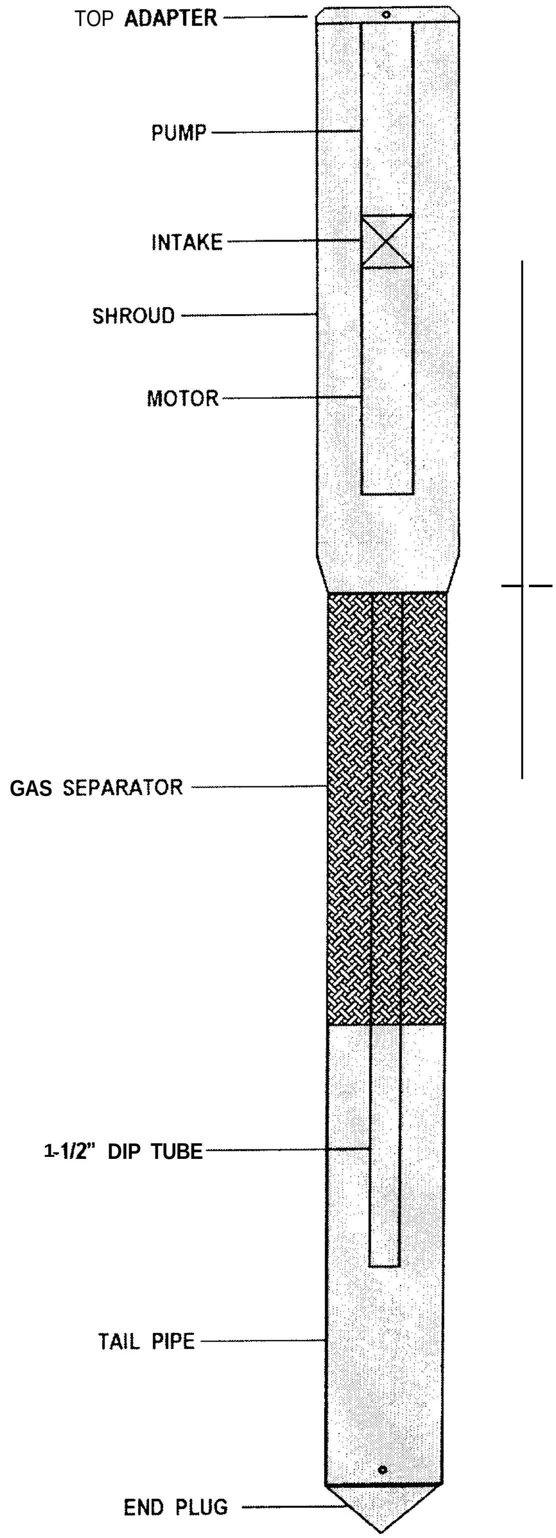
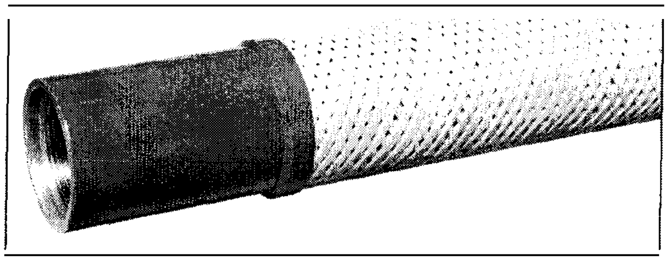
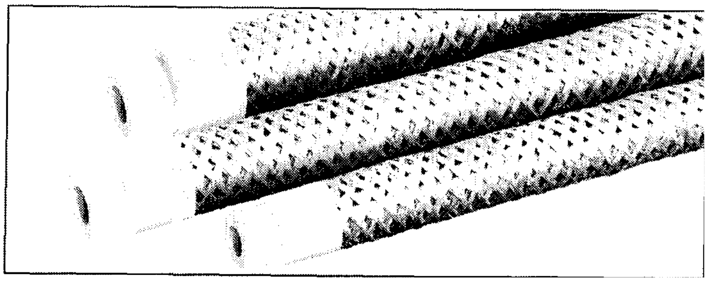


Figure 5



Product	Length	Weight	O.D.	I.D.	Connection
GS-3.0	76"	32 Lbs.	3.1"	1.875"	2-3/8"
GS-3.5	76"	44 Lbs.	3.5"	1.995"	2-3/8"
GS-3.5A	76"	45 Lbs.	3.5"	1.995"	2-7/8"
GS-4.0	76"	52 Lbs.	4.0"	2.375"	2-7/8"
GS-5.0	132"	125 Lbs.	5.0"	3.5"	3-1/2"

Figure 6



The Stanley

Product	Length	Weight	O.D.	I.D.	Seating Nipple	Connection
SN-1.375	3 FT	2 Lbs.	1.40"	.75"	2-318"	1" Npt
SN-1.70	6 FT	5 Lbs.	1.80"	.85"	2-7/8"	1-1/4" Npt
SN-2.125	6 FT	8 Lbs.	2.20"	1.125"	3-1/2"	1-1/2" Npt

Figure 7

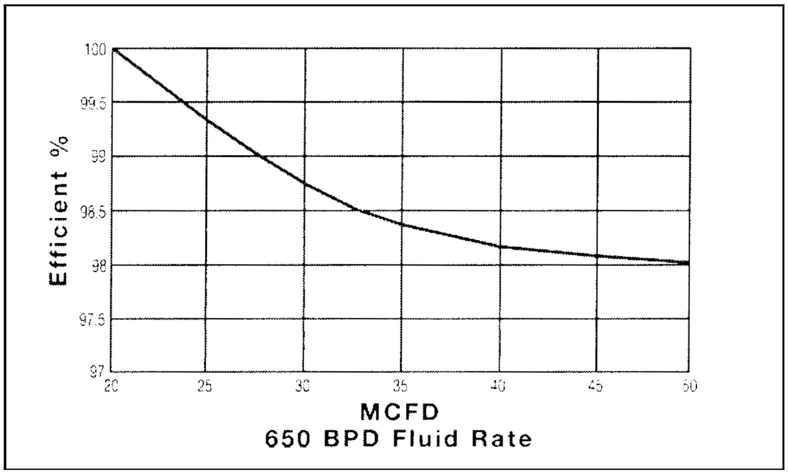


Figure 8

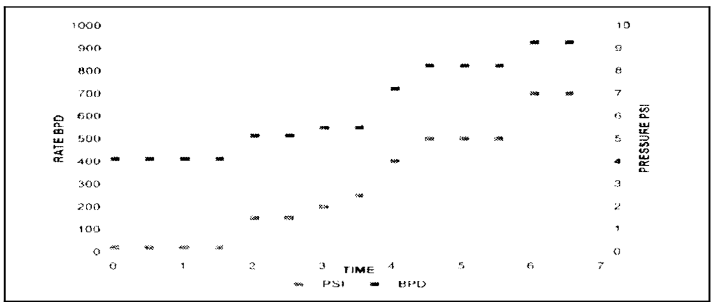


Figure 9

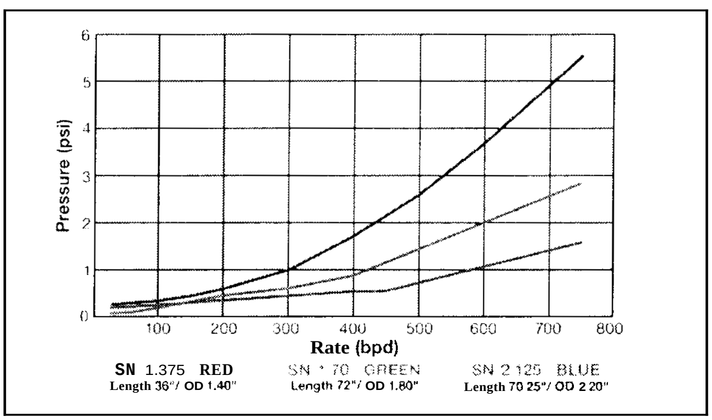


Figure 10

Energy Pump Supply, Inc
2798 Inland, Farmington NM 87401
505-564-2874

Pump Installation Schematic: SN & GS Below Perfs

Well: San Juan Co., New Mexico
Formation: Mesa Verde

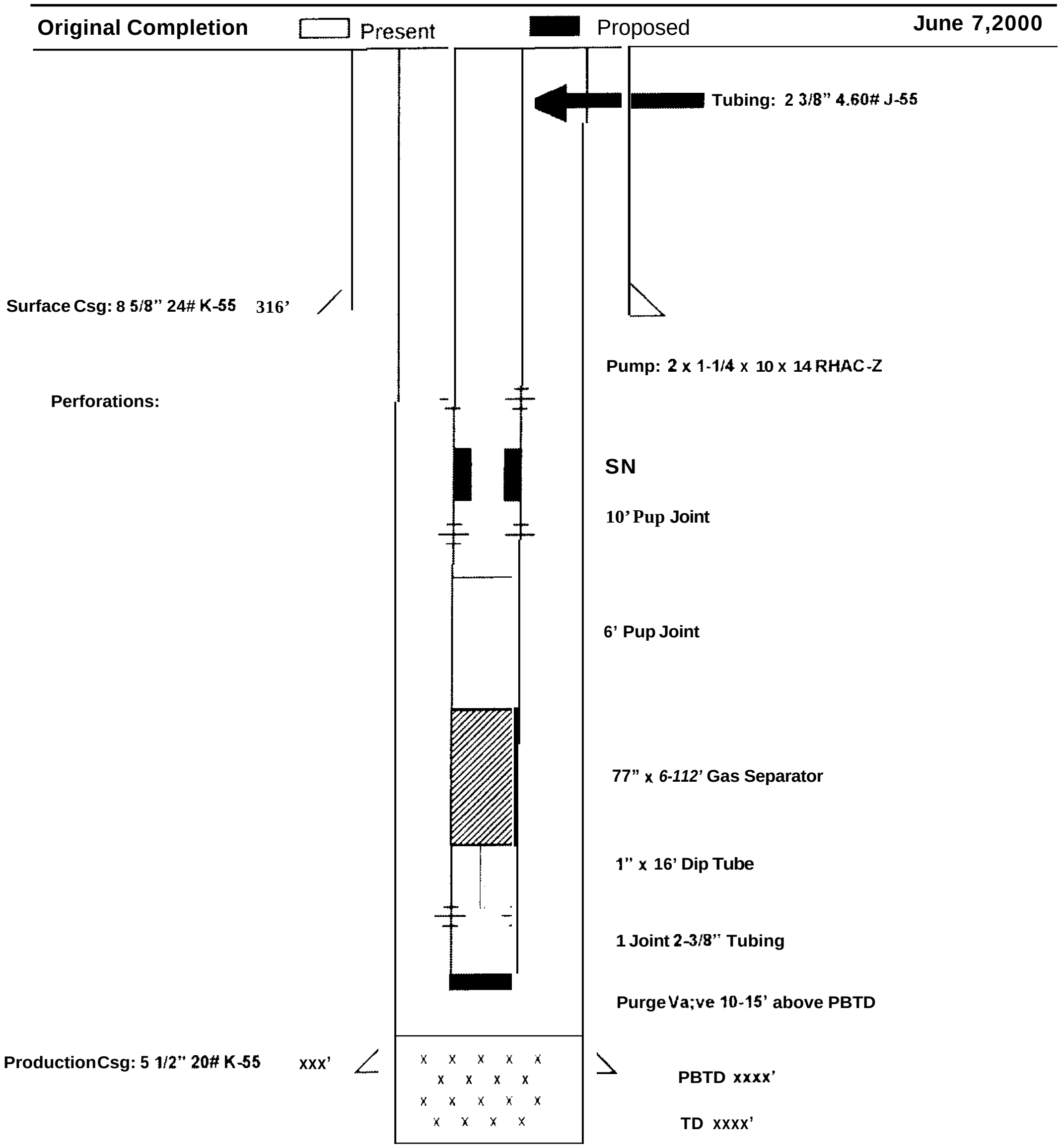


Figure 11

Test wells in San Juan Basin

	Before	After	% Change
Well A	145 BPD	150 BPD	+ 3.45%
Insert Pump	400 MCFD	550 MCFD	+ 37.5%
Well B	200 BPD	220 BPD	+ 10%
Insert Pump	500 MCFD	720 MCFD	+ 44%
Well C	200 BPD	250 BPD	+ 25%
Insert Pump	700 MCFD	1,100 MCFD	+ 57.14%

Data provided by Energy Pump, Huber, Devon and Burlington Resources

Figure 12

PC Test well Raton, New Mexico

	Before	After	% Change
Well A	200 BPD	306 BPD	+ 53 %
PC Pump	125 MCFD	346 MCFD	+ 176.80 %

Data provided by El Paso Oil & Gas & Wilson Supply Co.

Figure 13

Test wells in East Central Oklahoma

Efficiency - Reduction of gas volume produced up the tubing

	Before	After	% Change
Well 4	54 BPD	62 BPD	+ 13 81%
Insert Pump	76 MCFD	1 5 MCFD	- 98 03%
Well B	42 BPD	44 BPD	+ 4 76%
Insert Pump	42 MCFD	6 1 MCFD	- 85 48%
Well C	71 BPD	02 BPD	+ 37 78%
Insert Pump	75 MCFD	2.6 MCFD	- 96 53%

Data provided by B Iport 011. Inc

Figure 14

Gas Separator Application Bottom Hold-Down

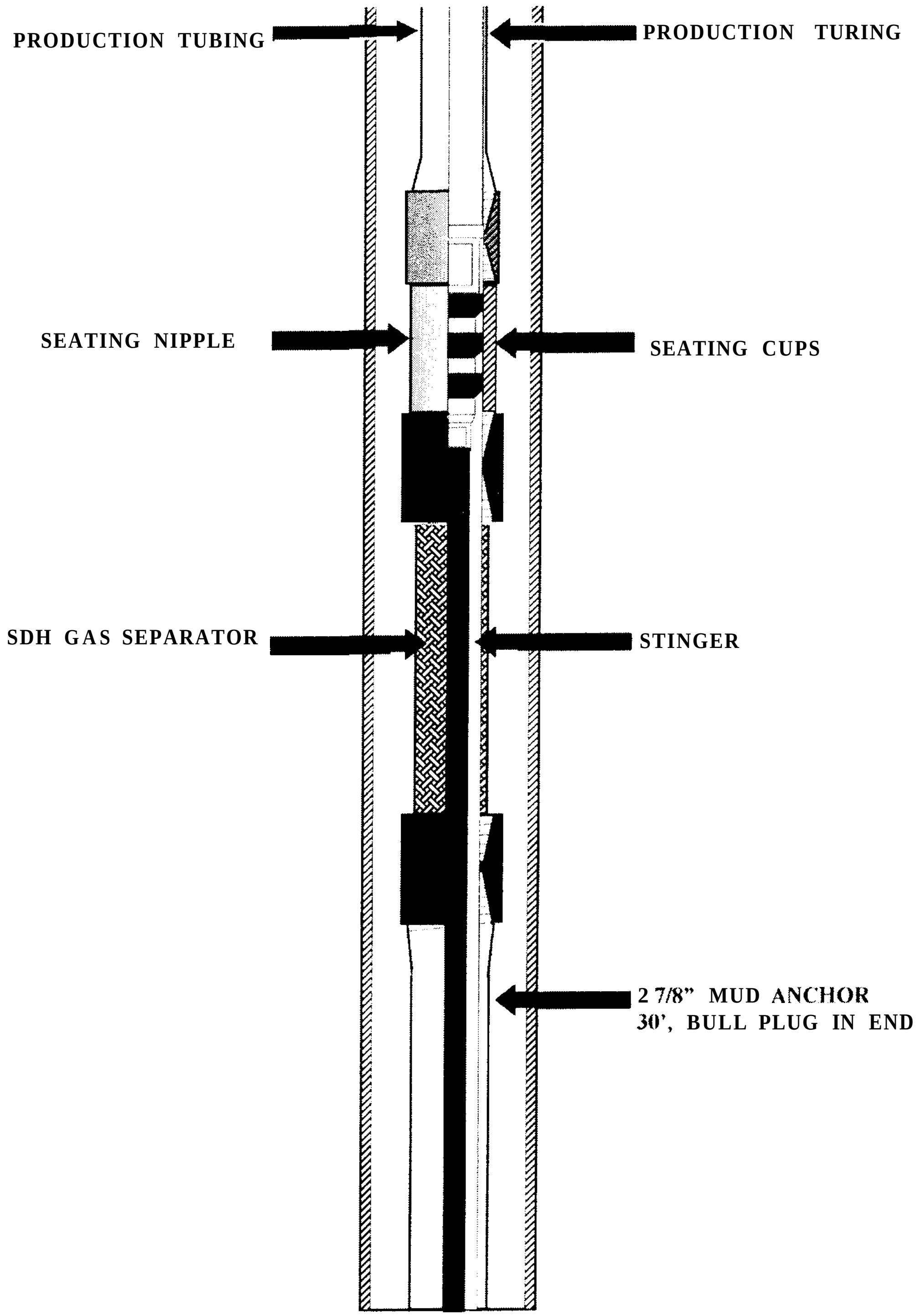
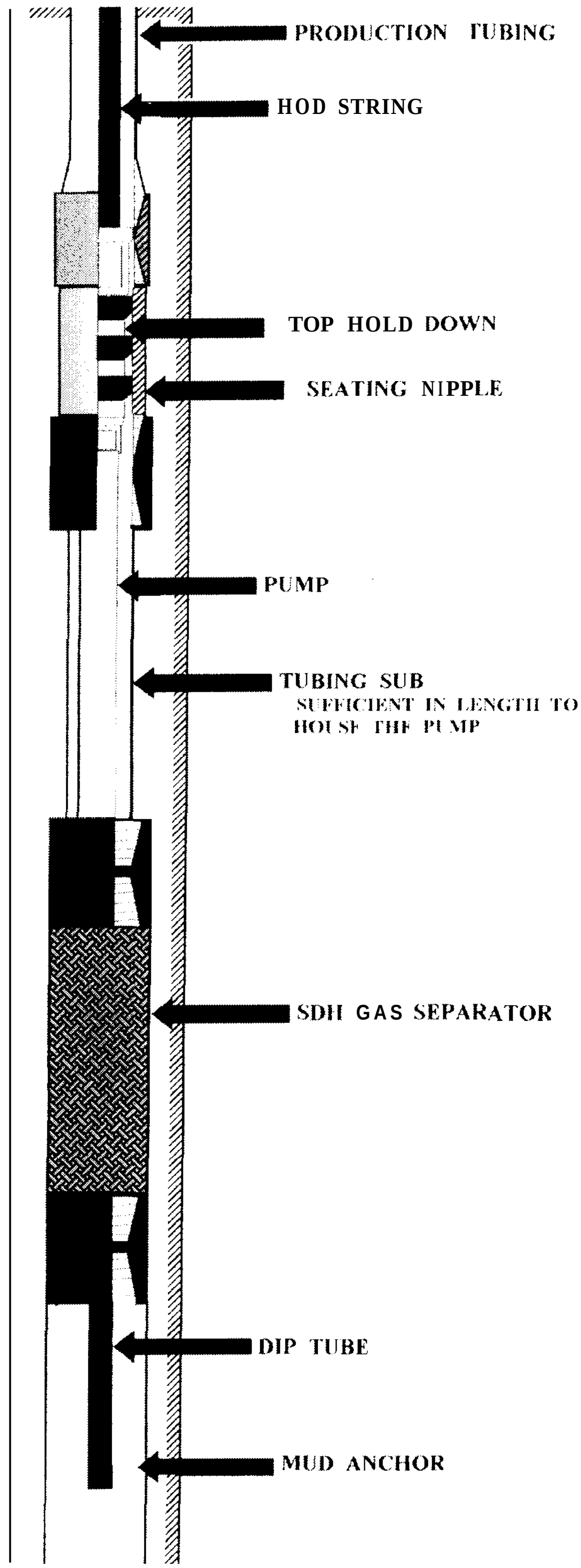


Figure 15

Top Hold-Down Application



Installation Instructions For GS-3.0 In 4-1/2" Cased Wells With Top Hold-Down Pumps

Due to annular space limitations we recommend using GS-3.0 (3") gas separators in all 4-1/2" cased wells. The inside diameter of this tool is 1-3/4" and will not accommodate a 2" insert pump. I you are installing a 2" insert pump with a GS-3.0 separator use the following installation.

Install a tubing sub. below the seating nipple. of sufficient length to accommodate the pump. Attach the gas separator just below the tubing sub followed by a closed end mud anchor. A 10-20 foot dip tube should be attached to the bottom of the pump.

Figure 16

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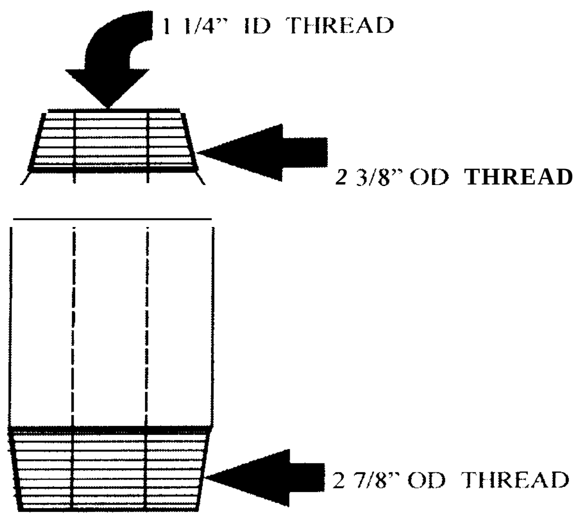
Gas Separator Applications for Progressive Cavity Pumps

The gas separator **is** attached below the stator by means of **a** short landing **sub** and the Stanley **PC** adapter. A 21' dip tube **is** inserted into the PC adapter prior to installing the gas separator. Attach a 30' closed end **mud** anchor below the gas separator.

No. PCA2875-1



PC ADAPTERS

PCA2875-1 2-7/8 **x** 2-3/8 **x** 1-1/4
PCA2875-2 2-7/8 **x** 2-7/8 **x** 1-1/2

Use 1-1/4" x 21' Dip Tube with PCA2875-1
Use 1-1/2" x 21' Dip Tube with PCA2875-2

*** Fluid volume over 300 BPD**
We recommend using two separators.

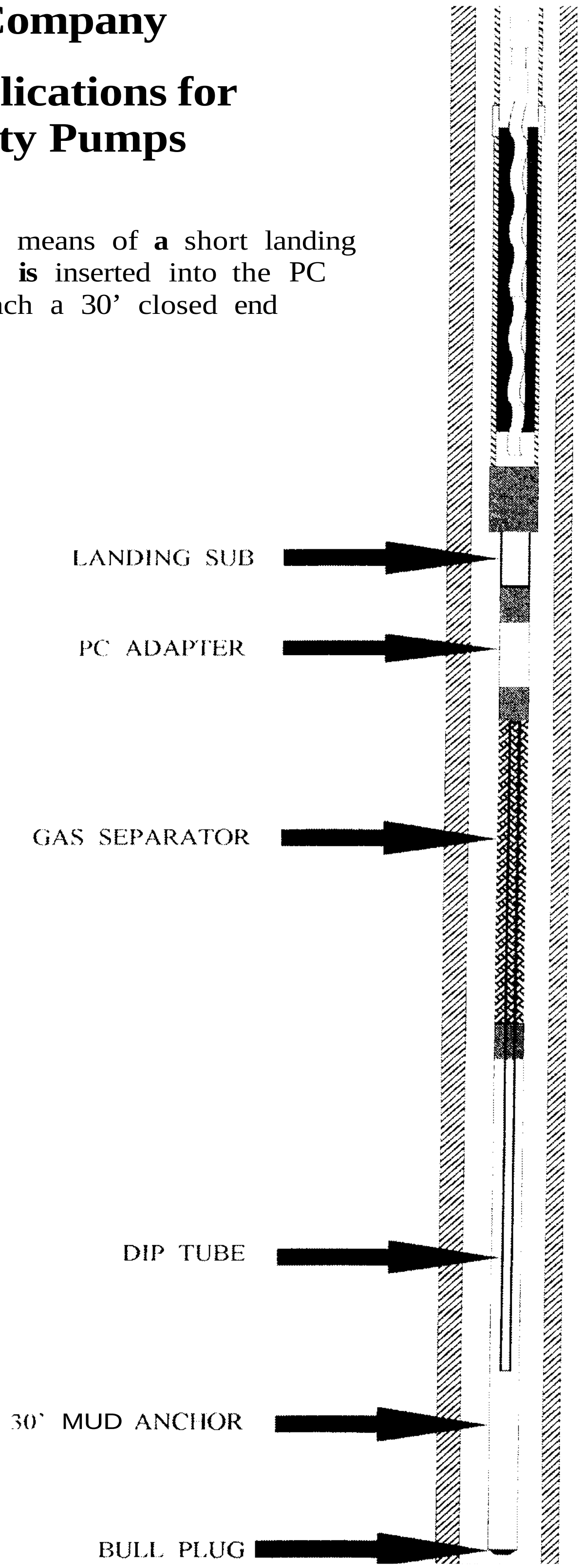


Figure 17

Stinger Application Below Perforation

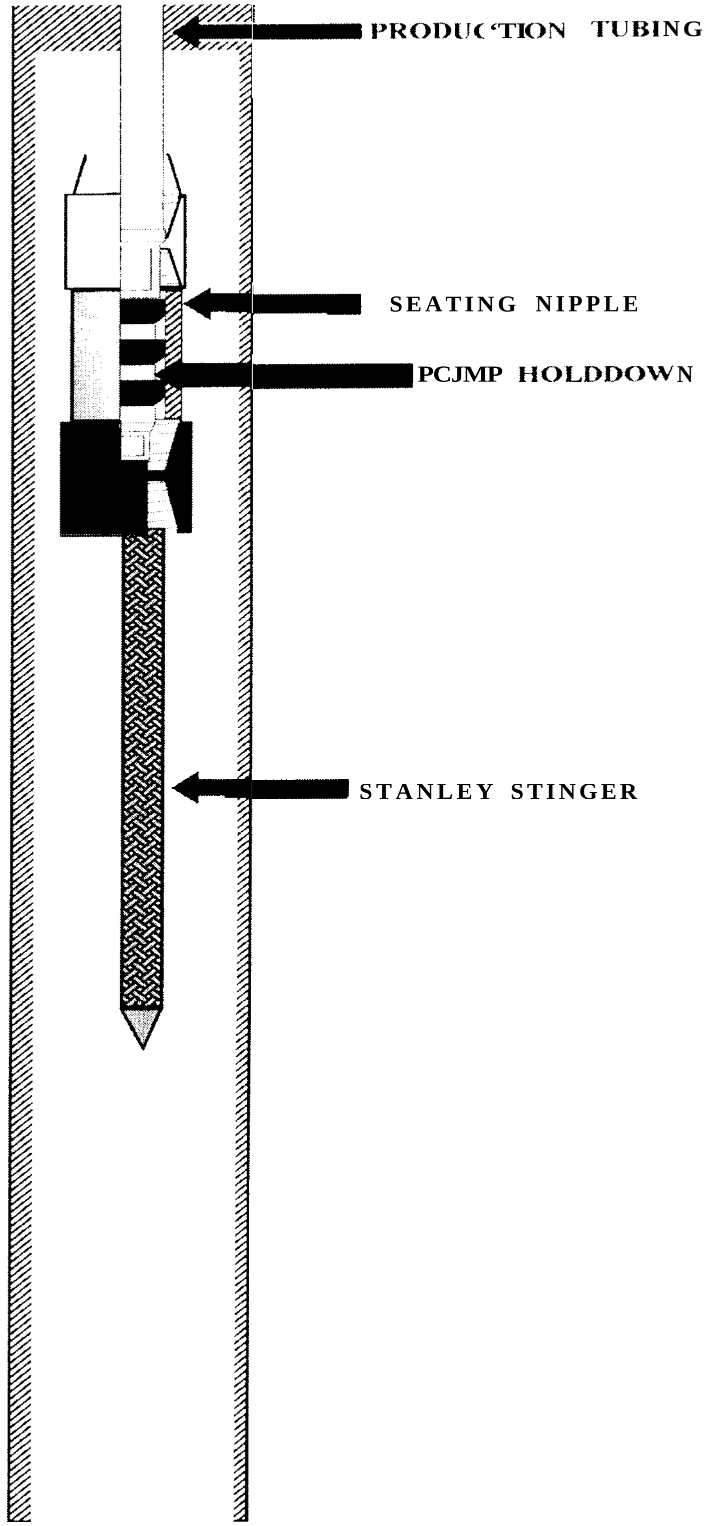


Figure 18