THE EFFECT RELIEVING CASING PRESSURE HAS ON BOTTOMHOLE PRESSURE

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Permian Production Equipment, Inc.

ABSTRACT

We will show in multiple case studies the effect of relieving back pressure on an oil well has in relationship to the producing bottomhole pressure, pump efficiency and over all economics of the well. This will be done by utilizing a Beam Gas Compressor®, BGC.

HISTORICAL DEVELOPMENT

Doing a fluid shot with an echometer device has long been the standard for determing the amount of fluid above the pump, pump efficiency, downhole pressures and many other items. In this paper we will discuss the changes that occur when the casing pressure is minimized by utilizing a Beam Gas Compressor® or BGC. The BGC uses a single cylinder to reduce the pressure in the annulus of the sucker rod pumped well and then discharges the gas back into the surface flowline or sales line. The resulting removal of the backpressure on the formation allows more gas to flow at a quicker rate, while also improving the efficiency of the downhole pump with greater fillage percentages. The pumping unit uses the torque creation of its prime mover at the middle of each stroke and the BGC takes advantage of this torque at the top and bottom of the stroke.

BASIC DESCRIPTION

To properly design a rod string you must understand how the well will react when pressure is added, via a choke, or reduced via venting or use of a BGC. Many people operate with the theory adding back pressure can reduce gas interference where by the exact opposite is true under the right conditions. You can often see how a well was originally designed does not work out to optimization. That is the point of continuing to do fluid shots at a consistent time period to see how the well changes as it produces. Producing rates can be estimated within the desired range of accuracy using the IPR technique with two stabilized producing rates and corresponding stabilized producing pressures. This makes it possible to use the IPR without needing to shut in the well and lose production to obtain shut-in information. Obtaining a bottomhole pressure equal to 10% of the shut-in reservoir pressure is recommended for determining maximum production rates for sucker-rod lifted wells. At this pressure, the maximum well productivity will be 97% of the well's theoretical maximum production rate.

LET'S FIRST LOOK AT THE PARTS OF A FLUID SHOT REPORT

The report consists of two pages Liquid Level (fig. 1) and the Dyno Page (fig. 2)

The Liquid Level pages shows how many feet above the pump the liquid is and how much free gas is in that liquid. It also shows the amount of casing pressure and annular gas flow. This is important as you can easily determine if a well is slugging gas up the tubing by comparing this information to the amount of gas the well is selling.
Also you can gather the producing bottom hole pressure (PBHP) and the static bottom hole pressure (SBHP). Often the SBHP is not attainable unless the well has been shut down for a period of time.
You can also see the pressure rate of gas buildup, this is important when sizing the right size of wellhead compressor.

The Dyno Page shows the effectiveness of the downhole pump, rod loading and gas displacement. You will see how much pressure is being placed on the Tubing by possibly using a choke and the pressure on the Casing. The

Casing pressure is generally the same as flowline. Beam Loading is also indicated on this page, as well as, FoMax (which is the optimum level of fluid production).

NOW LET'S LOOK AT THE HOW DESIGN SOFTWARE SHOWS IT SHOULD OPERATE

In Figure 3 you can see how the original design of the rod string would generate the capabilities of the well. This information is gathered by looking at the current rod string and the pumping unit. This would be the maximum capacity of this unit. Let us compare that with the fluid shots taken before the BGC was installed. It is easy to see that the structure of the well could produce much more oil and gas if the formation was able to move the fluid to the well bore. The pressures in the formation may no longer be sufficient.

LET'S LOOK AT THE BEFORE FLUID SHOTS

Most notably you will see the amount of gas calculated to flow up the annulus. What percentage is this of the total reported by the operator? The difference is the amount of gas flowing up the tubing and creating the inefficiencies in the pump. With the installation of the BGC this will change as the majority of gas is drawn up the annulus.

In some versions you can see the amount of gas and fluid as it moves in the pump, Figure 4 a and b. The top photo shows a pump with gas interference and the bottom shows fluid now in the pump after installation of a Beam Gas Compressor. You can see the increase plunger travel which results in greater oil production as well as a fuller pump.

PBHP this number is very important to determine the amount of fluid increase you can achieve by lowering the casing pressure. A current IPR (Inflow Performance Relationship) is often difficult to obtain but a ratio can be derived by looking at the PBHP and the Pump Intake Pressure (PIP). Most people believe that the PBHP should be less than 10% of the static bottomhole pressure (SBHP) 1. This is to achieve maximum production. As wells are depleted the SBHP becomes a closer relationship to the PBHP and it must be artificially changed by using a form of wellhead compression if the well is to continue to be profitable. By artificially lowering the PBHP you can greatly increase the flow of fluid to the well bore.[i]

Casing pressure buildup is an interesting aspect as it will allow you how to set the timers or the pump off controller to maximize the effect of the lowered casing pressure. If for example a well operates 50 minutes on and 50 minutes off… the question would be how quickly does the well build back up to the original pressure… it may be necessary to adjust the run times to 25 minutes on and 25 minutes off to maximize the lowest continual casing pressure (LCCP)

By determing the LCCP it will allow for the well to have the greatest possible time in a 24 hour period with the lowest possible PBHP.

CASE STUDIES

Number 1- The casing pressure was over 200 psig when a beam gas compressor was installed the casing pressure reduced over 132 points. The gas increase flowing up the annulus was 366 mcfd. This well was sending a larger amount of gas up the tubing now the BGC is drawing it all up the annulus and providing more opportunity for pump fillage.

Pump Intake and Producing Bottom Hole Pressure decreased in excess of 180 psig. This allowed for an increase in oil flow from the formation to the well bore and then up the pump as it no longer was clogged with gas.

The amount of pressure at the gas/liquid interface decreased by over 125 psig with a resulting lowering of the liquid level by 600 feet. This lowering of the liquid level is also part of the lowering of the producing bottom hole pressure.

Number 2- In this case it is easy to see the increase of the velocity of gas now being produced in the well bore. This increased velocity will aid in the use of gravitational separators. You can also see the full amount of gas is now traveling up the well bore and no longer up the tubing.

Number 3- In this case you also have a lowering of casing pressure and a subsequent increase of fluid production which is attested to by increase run time. You also see an increasing of bottom hole pressures which is attributed to the increase fluid level and more fluid coming to the well bore.

You can also see the loading of the pumping unit is lessened by the use of the BGC. In the pumping action of the sucker rod pumping unit on its upstroke the BGC is also compressing gas into the same fluid flow line. Thereby reducing the restriction the fluid has to move thru the line.

With the lowering of the loading you see a subsequent reduction of horse power usage.
Interesting enough here you get an increase of PBHP as more fluid is now in the wellbore.

Number 4- As in the previous examples a reduction of casing pressure resulted in an increase oil and gas production and reduction in loading and horsepower usage.

Number 5- This well also shows an increase of the velocity of gas, lower casing pressure, greater production and a reduced PBHP. . This is interesting when looking at the effect gravitational gas separators have on the production of a rod pumped well… Most of them depend on the velocity of the gas to escape their fluid captors to rise to the surface. If the velocity is not great enough it will stay in the fluid and go up the pump. In all of the case studies you see a tremendous increase in the velocity of the gas as shown by the echometer system.

Number 6- This case also shows the increase of the velocity of gas. This will allow a customer who has previously invested into a separator to now increase the effectiveness of that piece of equipment by installing a BGC. It also shows that reducing the backpressure would increase the drawdown and the well productivity[ii].

IN CONCLUSION

Reduction of casing pressure has long been proven as a means for increasing oil production. The main way of doing that was by opening the vent pipe and releasing the back pressure to atmosphere. With the Beam Gas Compressor you are able to accomplish the same purpose but environmentally safely capture the gas and get rid of the pressure. By utilizing testing equipment you can easily see the effect of lowering casing pressure on a well bore. The interesting applications are the lowering of the loading and horsepower for the pumping unit which should translate to a longer life and less breakdown of the pumping unit and rod string.

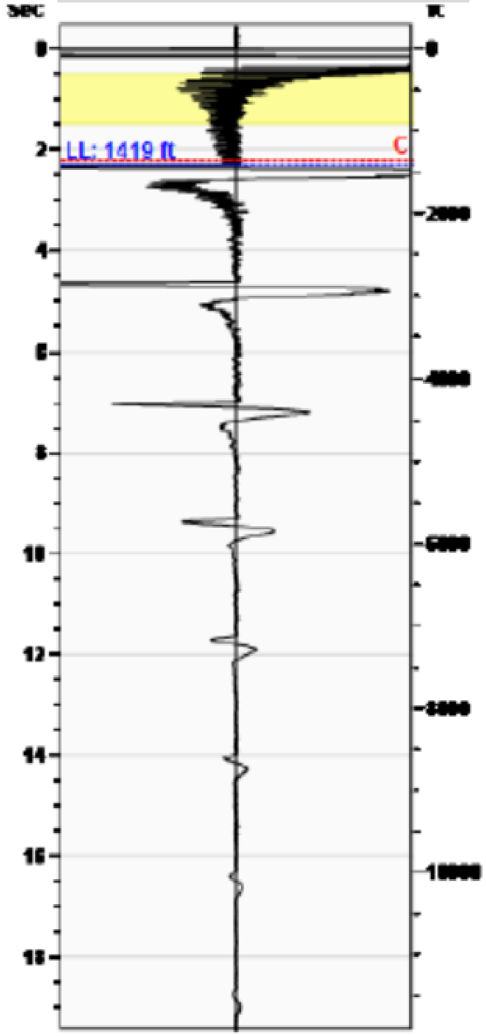
Another method of effecting a change on the bottomhole pressure was to put significant back pressure on the tubing. This cause premature packing failure and often rod collapse and pump failures. This also can be minimized by using a BGC to reduce casing pressure and thereby increase the differential between well bore and formation.

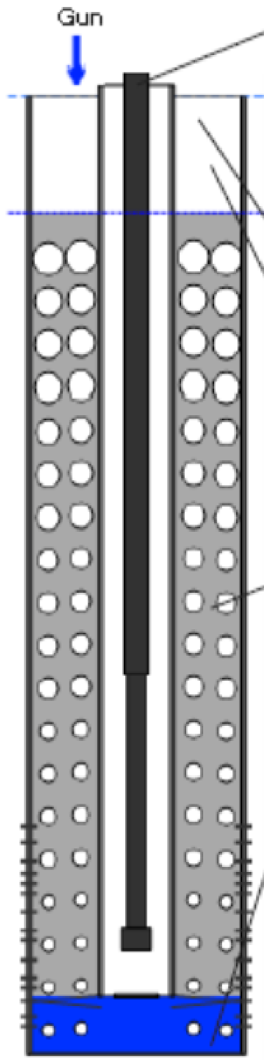
In addition the showcase of increasing the velocity of the gas up the annulus can only be seen as a tremendous way to minimize the amount of gas going up the tubing. Many companies have installed “Mother Hubbard” or Gas Separators. These devices are very effective until the gas velocity reduces with a BGC you can artificially increase this velocity and enjoy greater separation of fluid and gas for a longer duration.

Liquid Level	1419 ft

Fluid Above Pump	9486 ft
Equivalent Gas Free Above Pump	2301 ft

Figure No. 1





Production

Date Entered			04/21/15
	Current	Potential	
Oil	250	*.*	BBL/D
Water	150	*.*	BBL/D
Gas	115.0	*.*	Mscf/D
IPR Method			Vogel
Producing Efficiency			0.00%

Casing Pressure

Pressure 63.6 psi (g)

Annular Gas Flow

Gas Flow 96.0 Mscf/D

Fluid Properties

% Liquid Above Pump	24.26%
% Liquid Below Pump	49.81%

Wellbore Pressures

PIP	831.9 psi (g) @ 10905 ft
PBHP	926.3 psi (g) @ 11322 ft
SBHP	*.*
Gas/Liq Interface	66.5 psi (g) @ 1419 ft

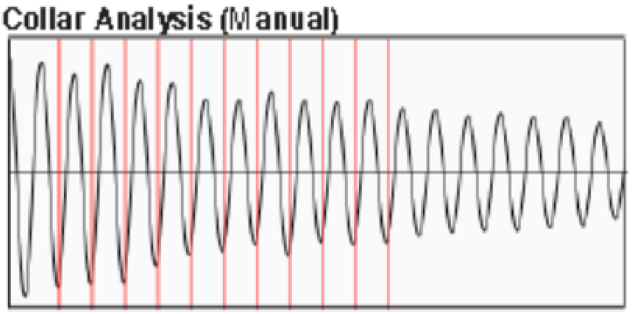
Depths

Pump Intake Depth	10905 ft
Formation Depth	11322 ft

Sensor Serial No.

LSHOOTER (WRFG 196)

Collar Analysis (Manual)



Average Acoustic Velocity	1225 ft/s
Average Joints Per Sec.	18.84 Jts/sec
Joints To Liquid	43.65 Jts

Casing Pressure Buildup

Casing Pressure	63.6 psi (g)
Buildup	2.4 psi (g)
Buildup Time	1 min 55 sec
Gas Gravity	0.7379 Air = 1

Comments and Recommendations

100% run time

Total Rod Concepts, Inc.
2600 SCR 1207
Midland, TX 79706
432-689-0300
www.TRCFiberflex.com

Beam

Loading	58.1%

Stroke

SPM	7.20 spm
Meas. Length	168.00 in

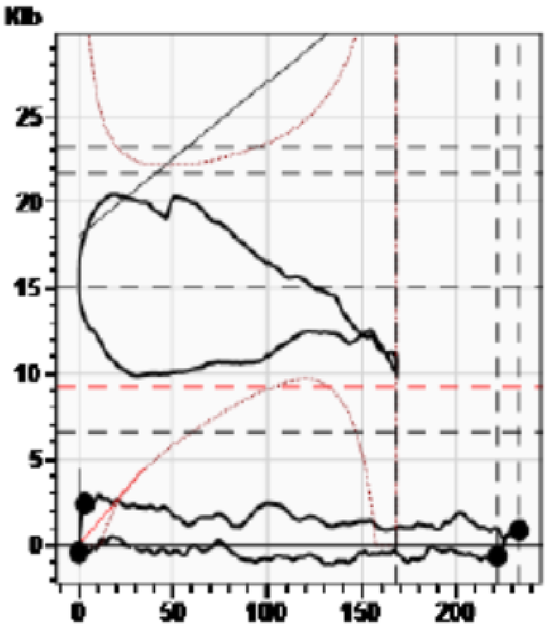
Polished Rod

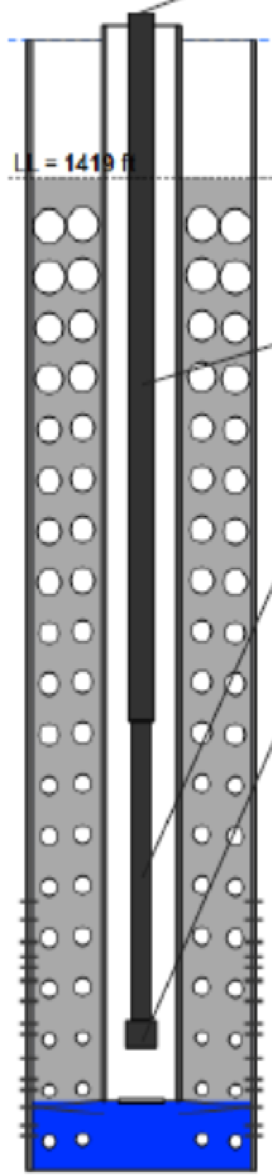
Peak Load	20465.1 lb
Min Load	9859.7 lb
Power	17.9 HP

Figure No. 2

Wellhead

Tubing Pressure	270.0 psi (g)
Casing Pressure	63.6 psi (g)





Rod Loading

Diameter (in) / Length (ft)	Grade	Modified Goodman (85%)	Stress (lb)	Sensitivity (85%, H)
1.25 7000	FG	48.0%	16676.5	83.2%
1 3075	D	48.1%	10063.2	44.4%
1.5 275	SB	14.5%	2013.5	6.6%

Pump (API: 0-150 R ?B? 30-4)

Max Stroke Length	233.72 in
Effective Plunger Stroke	221.91 in
Effective Fillage	94.9%
Effective Displacement	419 BBL/D
Calculated Fluid Load Max	9245.3 lb
Pump Fluid Load, Fo(Up-Dn)	1393 lb
Damp Up 0.15905	Damp Dn 0.15905
Kr	90 lb/in
Kt	595955 lb/in
Pump Intake Pressure	4443.4 psi (g)
Pump HP	8.5 HP

Production

Oil	250 BBL/D
Water	150 BBL/D
Gas	115 BBL/D

System Efficiencies

Polished Rod/Motor Eff.	*.*
Pump/Motor Eff.	*.*
Volumetric Eff.	94.9%

Comments and Recommendations

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432-689-0300
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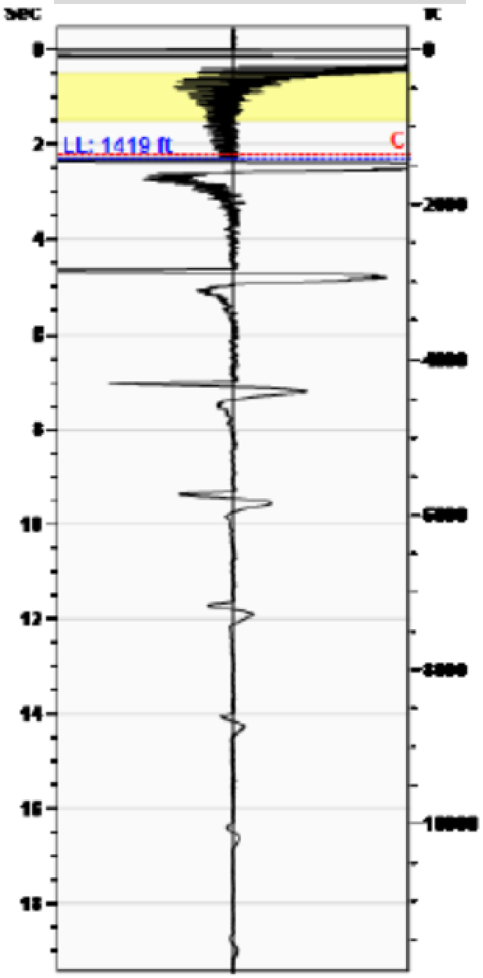
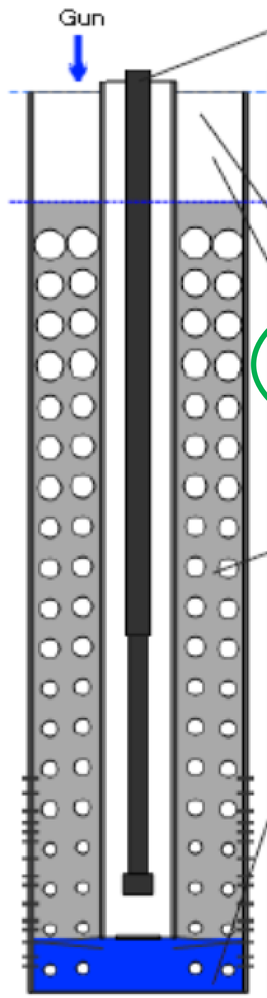
Liquid Level	1419 ft

Fluid Above Pump	9486 ft
Equivalent Gas Free Above Pump	2301 ft

Figure No. 1A





Production

Date Entered			04/21/15
	Current	Potential	
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Water	150	*.*	BBL/D
Gas	115.0	*.*	M scf/D
IPR Method			Vogel
Producing Efficiency			0.00%

Casing Pressure

Pressure	63.6 psi (g)

Annular Gas Flow

Gas Flow	96.0 M scf/D

Fluid Properties

% Liquid Above Pump	24.26%
% Liquid Below Pump	49.81%

Wellbore Pressures

PIP	831.9 psi (g) @ 10905 ft
PBHP	926.3 psi (g) @ 11322 ft
SBHP	*.*
Gas/Liq Interface	66.5 psi (g) @ 1419 ft

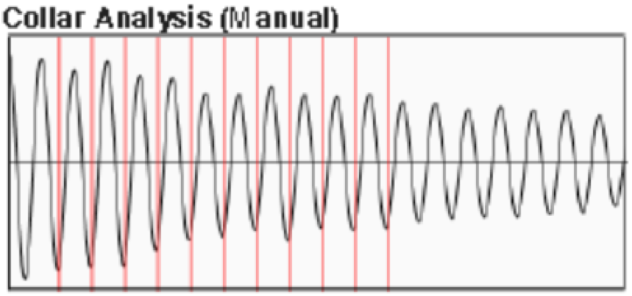
Depths

Pump Intake Depth	10905 ft
Formation Depth	11322 ft

Sensor Serial No.

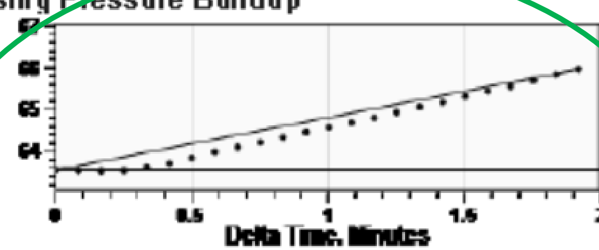
LSHOOTER (WRFG 196)

Collar Analysis (Manual)



Average Acoustic Velocity	1225 ft/s
Average Joints Per Sec.	18.84 Jts/sec
Joints To Liquid	43.65 Jts

Casing Pressure Buildup



Casing Pressure	63.6 psi (g)
Buildup	2.4 psi (g)
Buildup Time	1 min 55 sec
Gas Gravity	0.7379 Air = 1

Comments and Recommendations

100% run time

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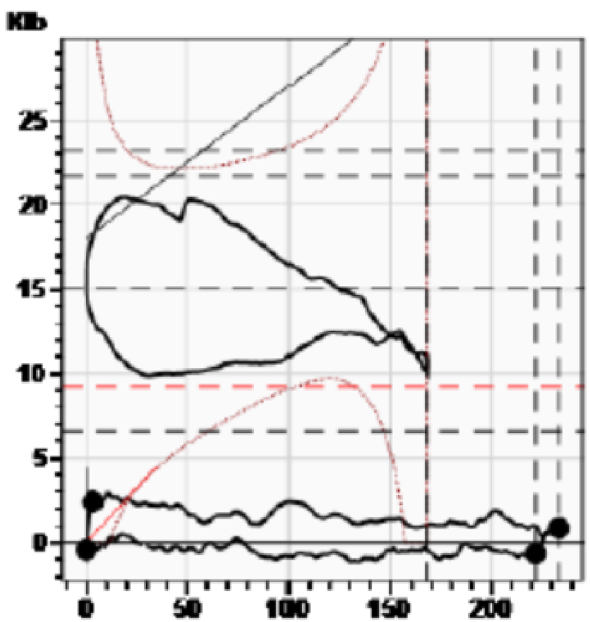
Beam
Loading 56.1%

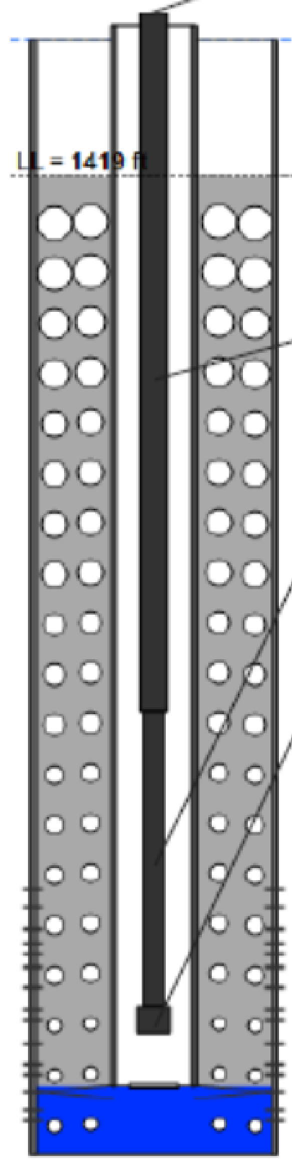
Stroke
SPM 7.20 spm
Meas. Length 168.00 in

Polished Rod
Peak Load 20465.1 lb
Min Load 9859.7 lb
Power 17.9 HP

Figure No. 2A

Wellhead
Tubing Pressure 270.0 psi (g)
Casing Pressure 63.6 psi (g)





Rod Loading

Diameter (in) / Length (ft)	Grade	Modified Goodman (85%)	Stress (lb)	Sensitivity (85%, H)
1.25 / 7000	FG	48.0%	1667[illegible].5	83.2%
1 / 3075	D	40.1%	1006[illegible].2	44.4%
1.5 / 275	SB	14.5%	2019.5	6.6%

Pump (API: 0-150 R ?B? 30-4)
Max Stroke Length 233.72 in
Effective Plunger Stroke 221.91 in
Effective Fillage 94.9%
Effective Displacement 419 BBL/D

Calculated Fluid Load Max 9245.3 lb
Pump Fluid Load, Fo(Up-Dn) 1393 lb
Damp Up 0.15905 Damp Dn 0.15905
Kr 90 lb/in
Kt 595955 lb/in

Pump Intake Pressure 4443.4 psi (g)
Pump HP 8.5 HP

Production
Oil 250 BBL/D
Water 150 BBL/D
Gas 115 BBL/D

System Efficiencies
Polished Rod/Motor Eff. *.*
Pump/Motor Eff. *.*
Volumetric Eff. 94.9%

Comments and Recommendations

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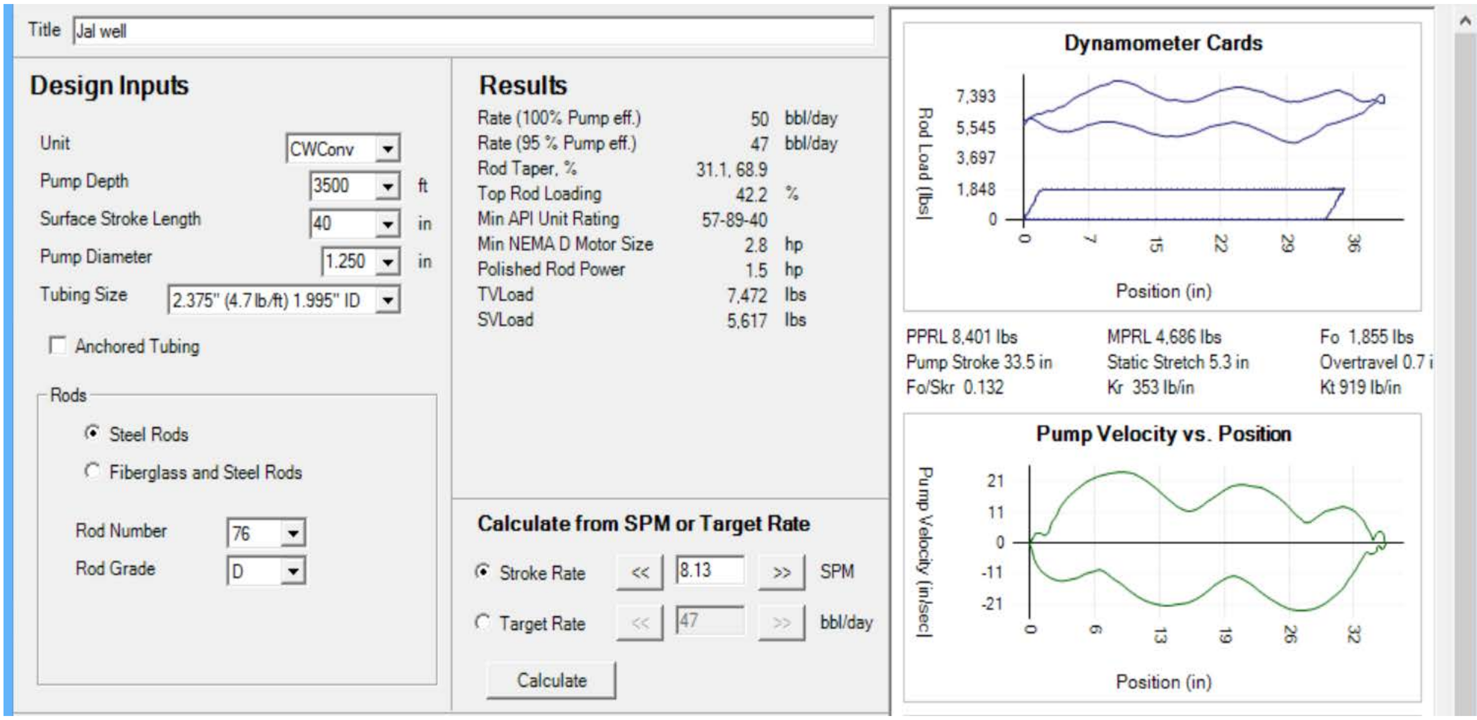
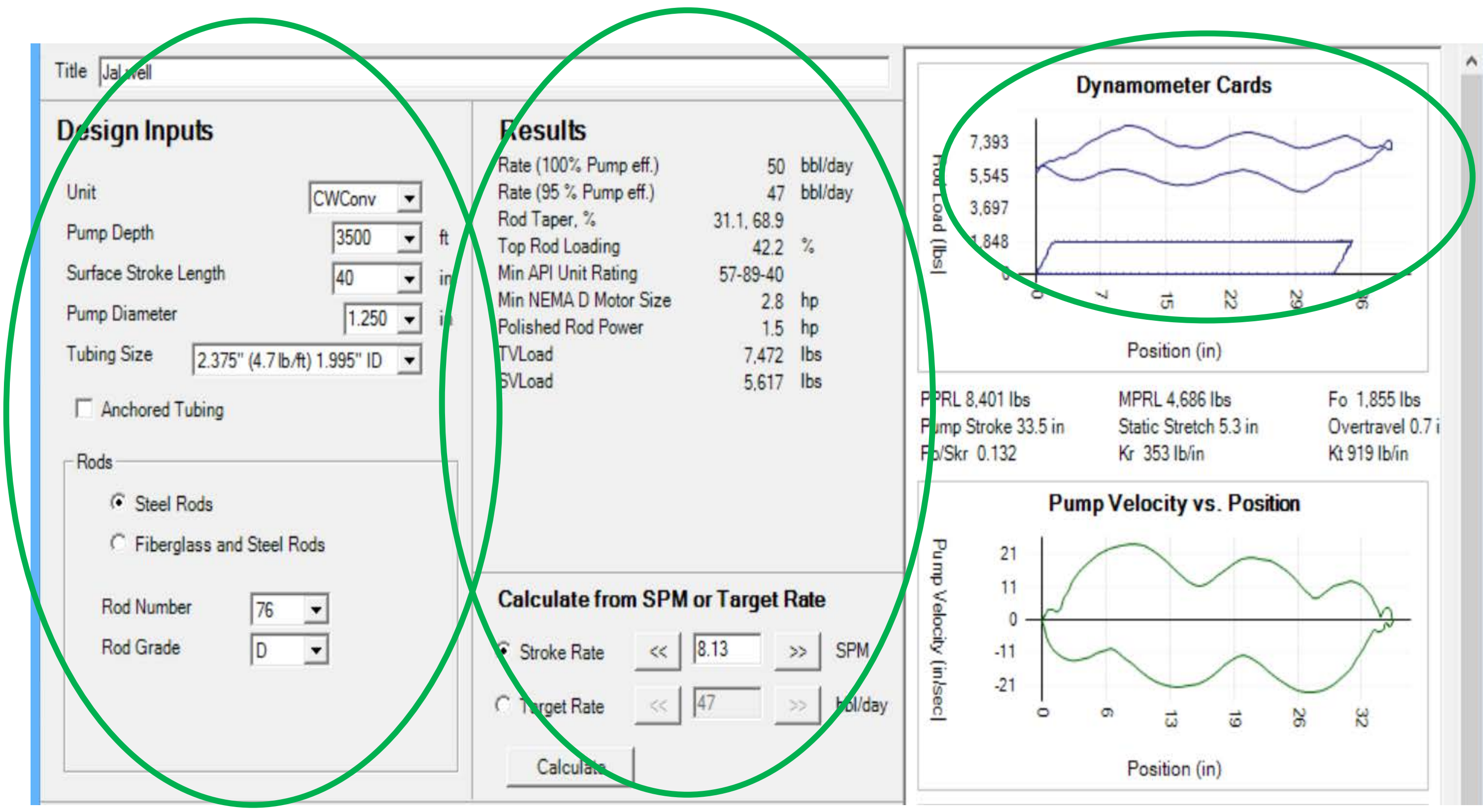
Figure No. 3

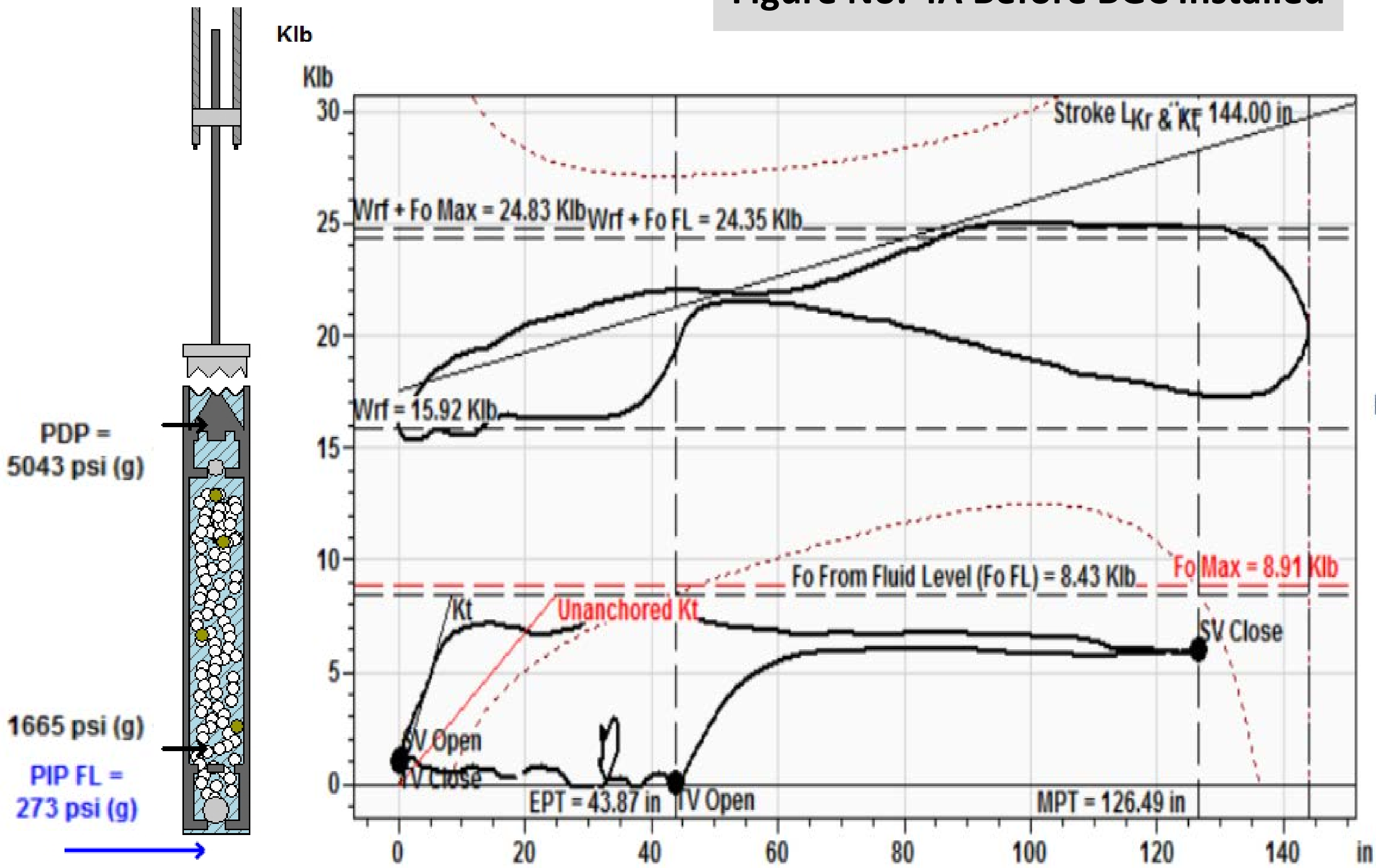


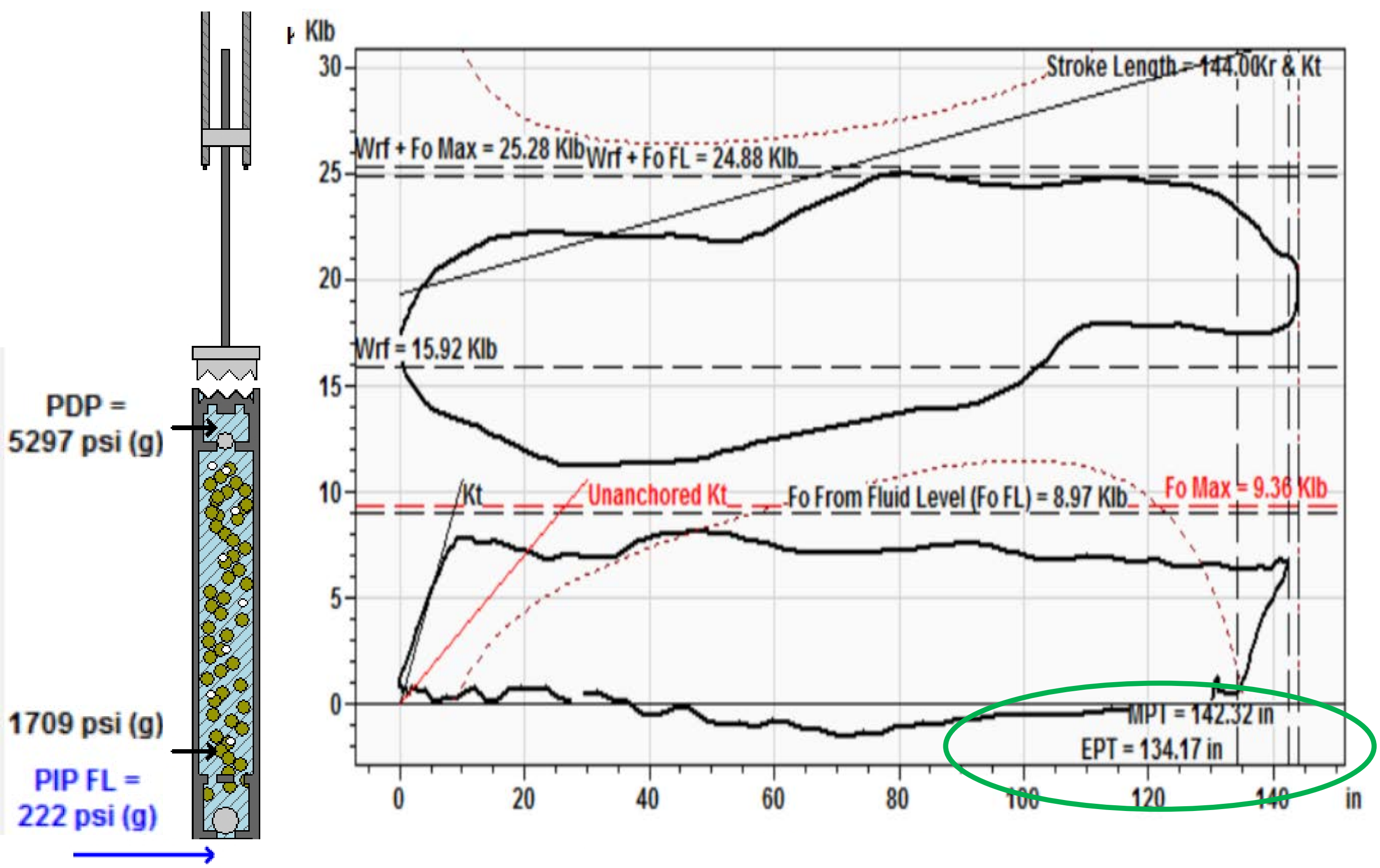
Title Jal well
Design Inputs
Unit CWConv
Pump Depth 3500 ft
Surface Stroke Length 40 in
Pump Diameter 1.250 in
Tubing Size 2.375" (4.7 lb/ft) 1.995" ID
Anchored Tubing
Rods
Steel Rods
Fiberglass and Steel Rods
Rod Number 76
Rod Grade D
Results
Rate (100% Pump eff.) 50 bbl/day
Rate (95 % Pump eff.) 47 bbl/day
Rod Taper, % 31.1, 68.9
Top Rod Loading 42.2 %
Min API Unit Rating 57-89-40
Min NEMA D Motor Size 2.8 hp
Polished Rod Power 1.5 hp
TVLoad 7,472 lbs
SVLoad 5,617 lbs
Calculate from SPM or Target Rate
Stroke Rate << 8.13 >> SPM
Target Rate << 47 >> bbl/day
Calculate
Dynamometer Cards
Rod Load (lbs)
7,393
5,545
3,697
1,848
0
0 7 15 22 29 36
Position (in)
PPRL 8,401 lbs
MPRL 4,686 lbs
Fo 1,855 lbs
Pump Stroke 33.5 in
Static Stretch 5.3 in
Overtravel 0.7 i
Fo/Skr 0.132
Kr 353 lb/in
Kt 919 lb/in
Pump Velocity vs. Position
Pump Velocity (in/sec)
21
11
0
-11
-21
0 6 13 19 26 32
Position (in)



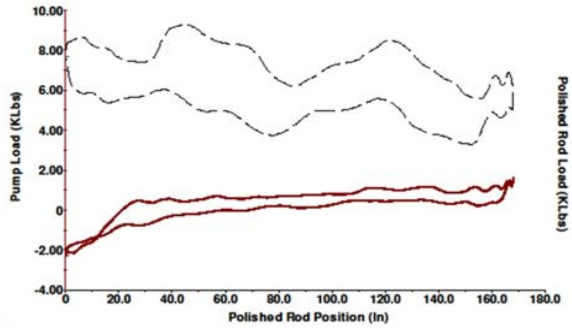
Title Jal well
Design Inputs
Unit CWConv
Pump Depth 3500 ft
Surface Stroke Length 40
Pump Diameter 1.250
Tubing Size 2.375" (4.7 lb/ft) 1.995" ID
Anchored Tubing
Rods
Steel Rods
Fiberglass and Steel Rods
Rod Number 76
Rod Grade D
Results
Rate (100% Pump eff.) 50 bbl/day
Rate (95 % Pump eff.) 47 bbl/day
Rod Taper, % 31.1, 68.9
Top Rod Loading 42.2 %
Min API Unit Rating 57-89-40
Min NEMA D Motor Size 2.8 hp
Polished Rod Power 1.5 hp
TVLoad 7,472 lbs
SVLoad 5,617 lbs
Calculate from SPM or Target Rate
Stroke Rate << 8.13 >> SPM
Target Rate << 47 >> bbl/day
Dynamometer Cards
7,393
5,545
3,697
0 7 15 22
Position (in)
PPRL 8,401 lbs
MPRL 4,686 lbs
Fo 1,855 lbs
Pump Stroke 33.5 in
Static Stretch 5.3 in
Overtravel 0.7 i
Fo/Skr 0.132
Kr 353 lb/in
Kt 919 lb/in
Pump Velocity vs. Position
Pump Velocity (in/sec)
21
11
0
-11
-21
0 6 13 19 26 32
Position (in)

Figure No. 4A Before BGC Installed





Case Study Number 1

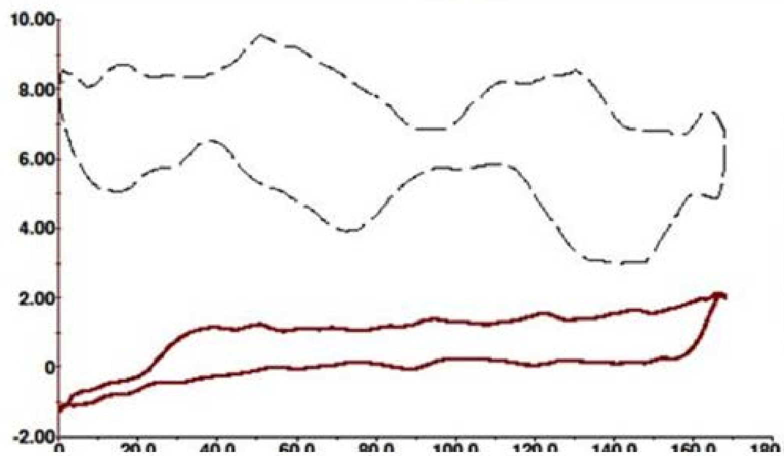


Casing Pressure
202.7 psi (g)
Casing Pressure Buildup
23.4 psi (g)
1.00 min
Gas/Liquid Interface Pressure
217.2 psi (g)
Liquid Level Depth
2740.31 ft
Pump Intake Depth
3574.00 ft
Formation Depth
3536.00 ft

Producing
Annular Gas Flow
67.5 MscFD
% Liquid
19 %

Pump Intake
285.1 psi (g)
Producing BHP
271.3 psi (g)
Static BHP
480.0 psi (g)

Formation Submergence
Total Gaseous Liquid Column HT (TVD) 834 ft
Equivalent Gas Free Liquid HT (TVD) 187 ft
Acoustic Test



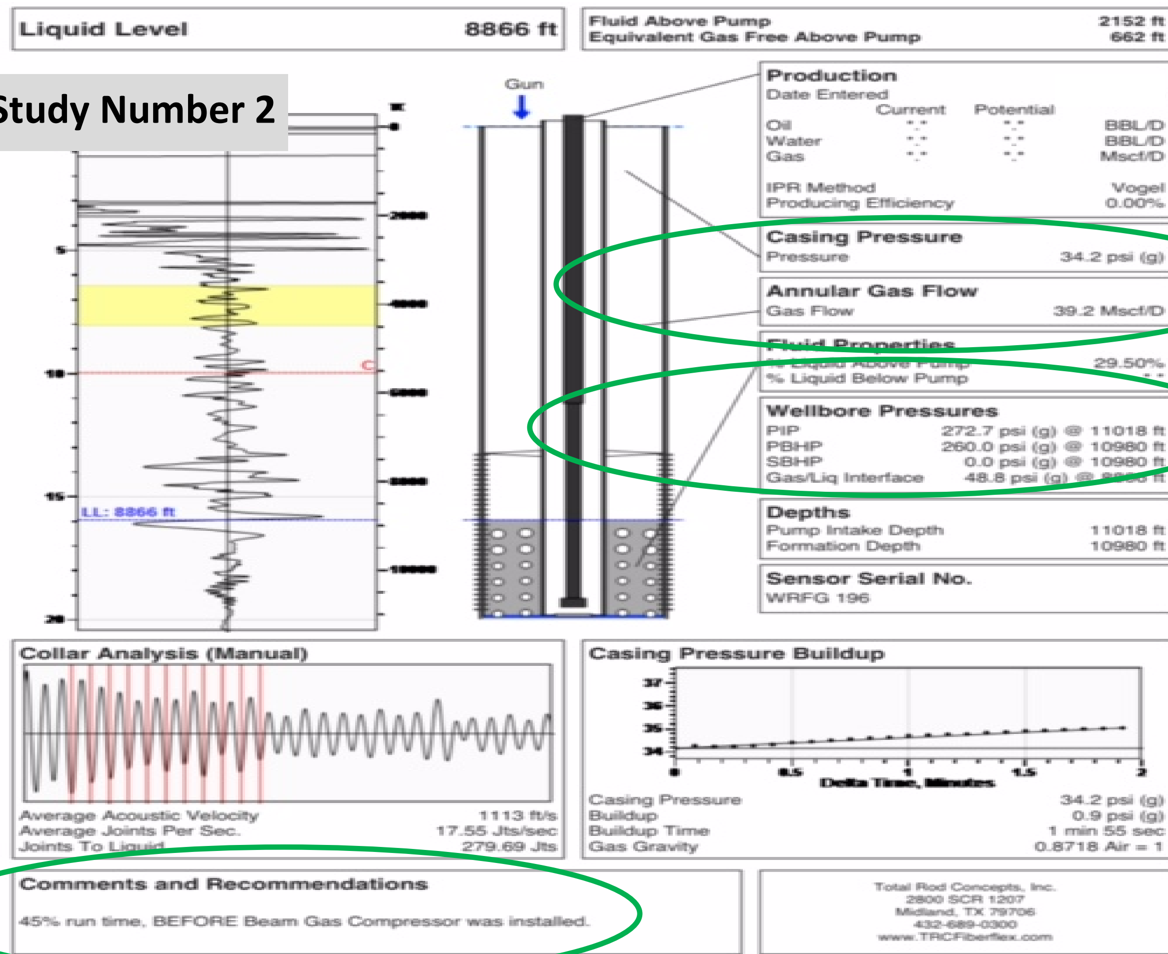
Casing Pressure
70.5 psi (g)
Casing Pressure Buildup
15.0 psi (g)
1.00 min
Gas/Liquid Interface Pressure
78.0 psi (g)
Liquid Level Depth
3384.07 ft
Pump Intake Depth
3574.00 ft
Formation Depth
3536.00 ft

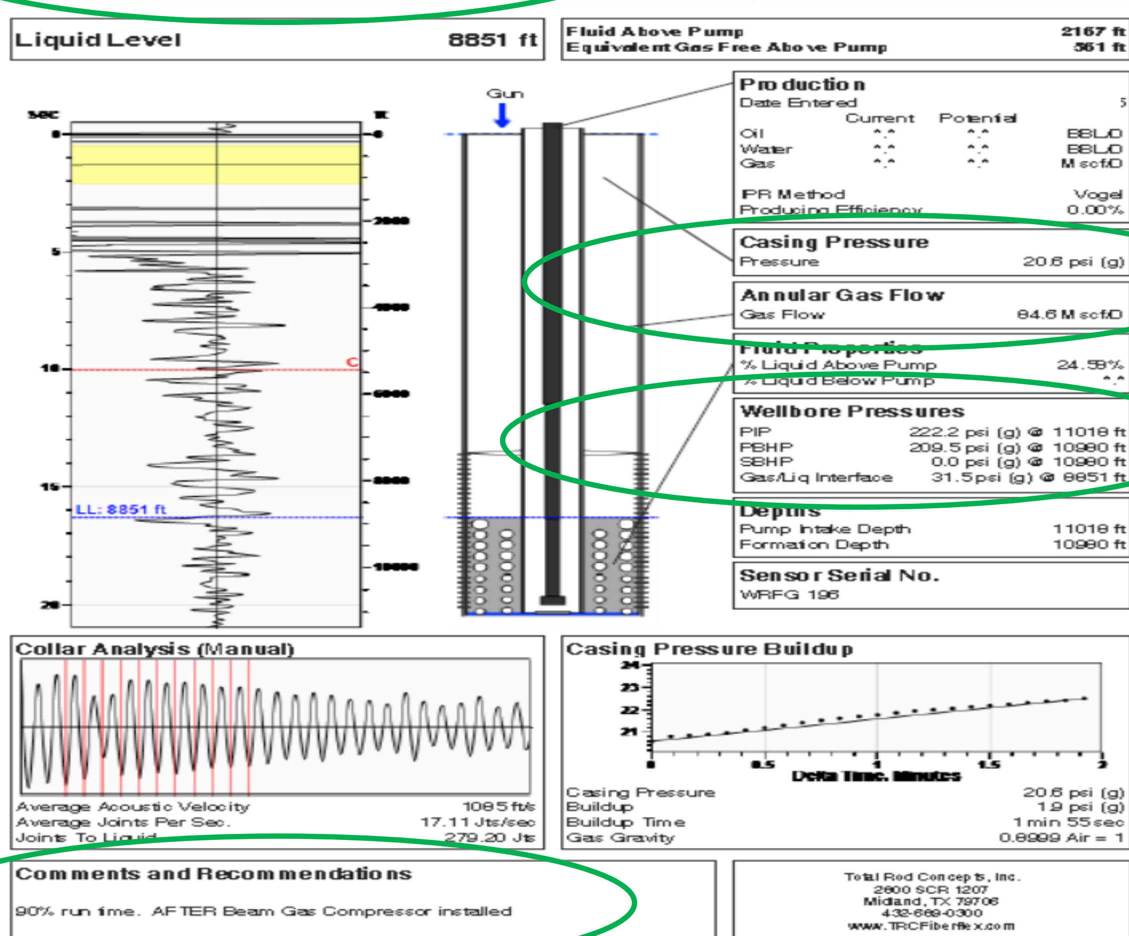
Producing
Annular Gas Flow
434 MscFD
% Liquid
19 %

Pump Intake
102.5 psi (g)
Producing BHP
88.6 psi (g)
Static BHP
397.3 psi (g)

Formation Submergence
Total Gaseous Liquid Column HT (TVD) 190 ft
Equivalent Gas Free Liquid HT (TVD) 67 ft
Acoustic Test

Case Study Number 2





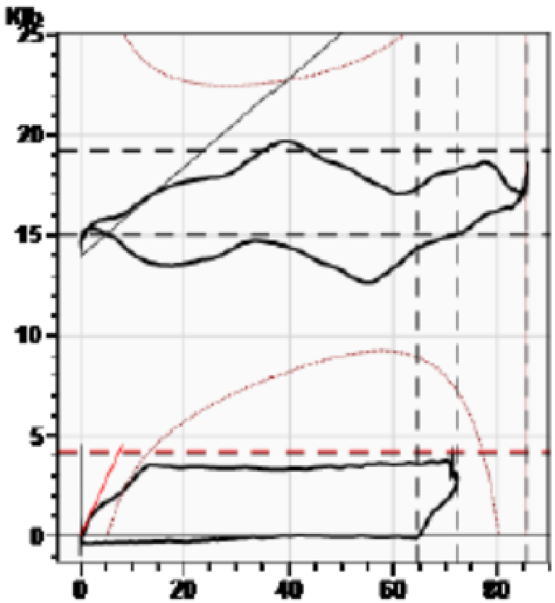
Case Study Number 3

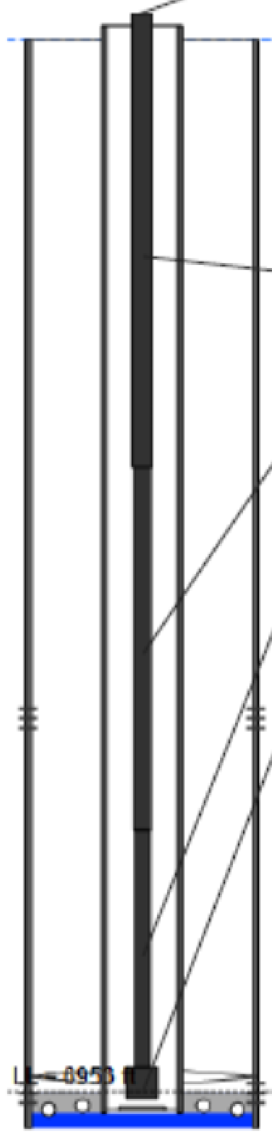
Beam
Loading 64.6%

Stroke
SPM 5.52 spm
Meas. Length 85.71 in

Polished Rod
Peak Load 19705.8 lb
Min Load 12654.1 lb
Power 4.1 HP

Wellhead
Tubing Pressure 220.0 psi (g)
Casing Pressure 30.3 psi (g)





Rod Loading

Diameter (in) / Length (ft)	Grade	Modified Goodman (95%)	Stress (lb)	Sensitivity (95%, H)
1 2025	D	48.7%	25030.2	53.0%
0.875 2400	D	40.3%	20068.8	47.2%
0.75 1575	D	44.8%	16271.1	39.8%
1.5 200	SB	12.2%	2755.7	6.5%

Pump (API: 0-125 R ?B? 24-4)
Max Stroke Length 72.42 in
Gas Free Plunger Stroke 64.65 in
Gas Free Fillage 89.3%
Gas Free Slippage 11 BBL/D
Gas Free Displacement 52 BBL/D

Calculated Fluid Load Max 4217.6 lb
Pump Fluid Load, Fo(Up-Dn) 3478 lb
Damp Factor 0.12070
Kr 226 lb/in
Kt 17737 lb/in

Pump Intake Pressure 603.0 psi (g)
Pump HP 3.2 HP

Production
Oil *.* BBL/D
Water *.* BBL/D
Gas *.* BBL/D

System Efficiencies
Polished Rod/Motor Eff. *.*
Pump/Motor Eff. *.*
Volumetric Eff. 89.3%

Comments and Recommendations

BEFORE BGC WAS INSTALLED

2 BBL/D
2 BBL/D
12 BBL/D

Total Rod Concepts, Inc.
2800 SCR 1207
Midland, TX 79706
432-689-0300
www.TRCFiberflex.com

Beam

Loading	63.0%

Stroke

SPM	5.94 spm
Meas. Length	85.71 in

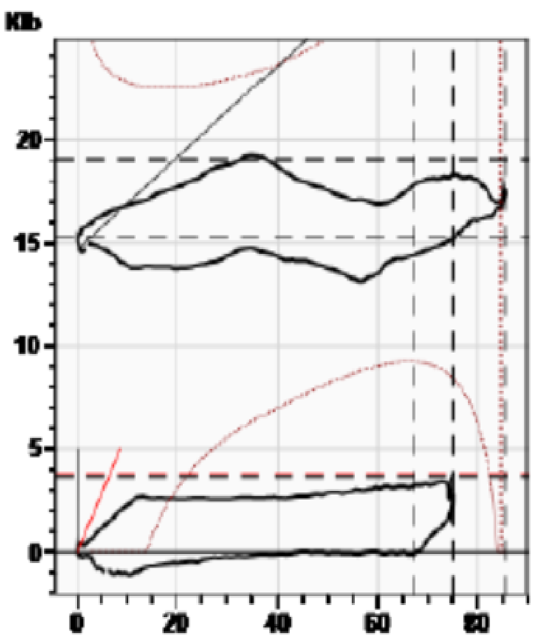
Polished Rod

Peak Load	19226.4 lb
Min Load	13122.0 lb
Power	4.1 HP

Case Study Number

Wellhead

Tubing Pressure	220.0 psi (g)
Casing Pressure	5.0 psi (g)



Rod Loading

Diameter (in) / Length (ft)	Grade	Modified Goodman (85%)	Stress (lb)	Sensitivity (85%, H)
1 2025	D	42.6%	24473.8	57.6%
0.875 2400	D	38.7%	13128.0	45.0%
0.75 1575	D	44.1%	15850.6	35.1%
1.5 200	SB	18.1%	2554.3	6.0%

Production

Oil	6 BBL/D
Water	5 BBL/D
Gas	15 BBL/D

Pump (API: 0-125 R ?B? 24-4)

Max Stroke Length	75.00 in
Gas Free Plunger Stroke	67.32 in
Gas Free Fillage	89.8%
Gas Free Slippage	10 BBL/D
Gas Free Displacement	61 BBL/D
Calculated Fluid Load Max	3753.7 lb
Pump Fluid Load, Fo(Up-Dn)	2873 lb
Damp Factor	0.12070
Kr	226 lb/in
Kt	17737 lb/in
Pump Intake Pressure	717.3 psi (g)
Pump HP	3.1 HP

System Efficiencies

Polished Rod/Motor Eff.	*.*
Pump/Motor Eff.	*.*
Volumetric Eff.	89.8%

Comments and Recommendations

AFTER BGC INSTALLED

Total Rod Concepts, Inc.
2600 SCR 1207
Midland, TX 79706
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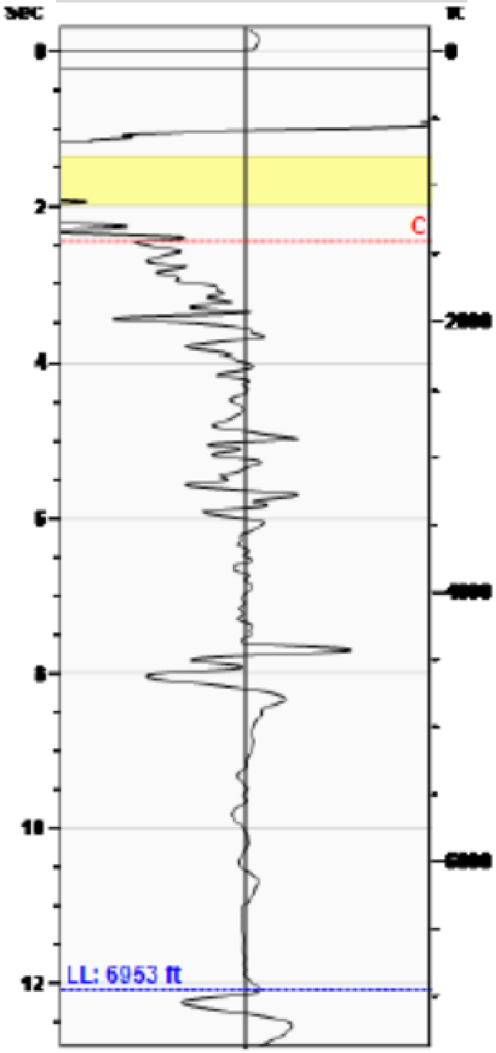
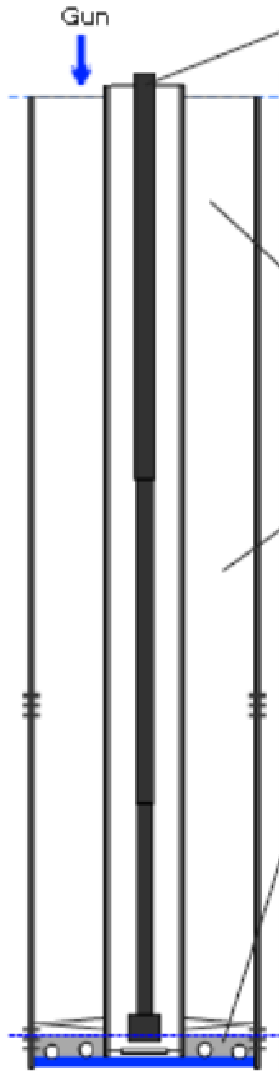
Liquid Level	6953 ft

Fluid Above Pump	117 ft
Equivalent Gas Free Above Pump	103 ft

Case Study Number 3





Production

Date Entered			05/27/15
	Current	Potential	
Oil	*.*	*.*	BBL/D
Water	*.*	*.*	BBL/D
Gas	*.*	*.*	Mscf/D
IPR Method			Vogel
Producing Efficiency			0.00%

Casing Pressure

Pressure	30.3 psi (g)

Annular Gas Flow

Gas Flow	2.7 Mscf/D

Fluid Properties

% Liquid Above Pump	87.14%
% Liquid Below Pump	*.*

Wellbore Pressures

PIP	75.0 psi (g) @ 7070 ft
PBHP	72.7 psi (g) @ 7063 ft
SBHP	*.*
Gas/Liq Interface	40.0 psi (g) @ 6953 ft

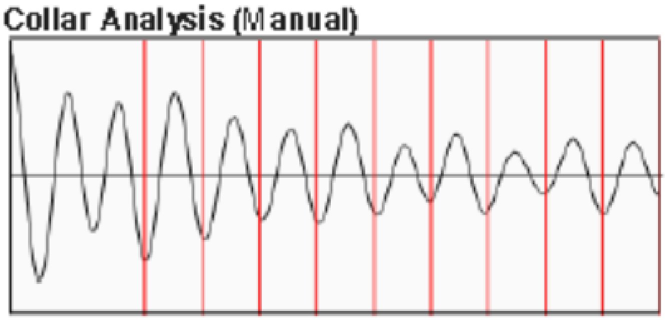
Depths

Pump Intake Depth	7070 ft
Formation Depth	7063 ft

Sensor Serial No.

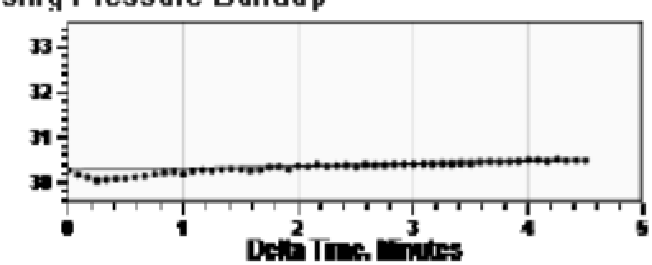
WRFG 196

Collar Analysis (Manual)



Average Acoustic Velocity	1150 ft/s
Average Joints Per Sec.	18.32 Jts/sec
Joints To Liquid	221.43 Jts

Casing Pressure Buildup



Casing Pressure	30.3 psi (g)
Buildup	0.2 psi (g)
Buildup Time	4 min 30 sec
Gas Gravity	0.8440 Air = 1

Comments and Recommendations

80% RUN TIME. BEFORE BGC WAS INSTALLED

2 BBL/D
2 BBL/D
12 BBL/D

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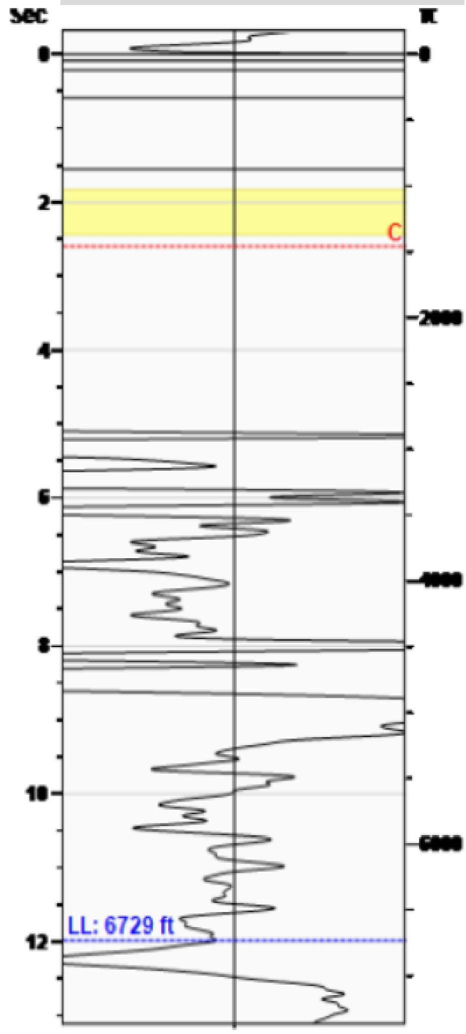
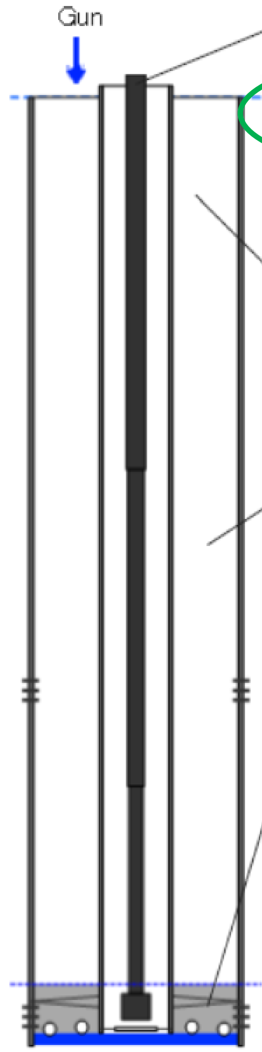
Liquid Level	**6729 ft**

Fluid Above Pump	**341 ft**
Equivalent Gas Free Above Pump	**265 ft**

Case Study Number 3





Production

Date Entered			06/16/15
	Current	Potential	
Oil	6	*.*	BBL/D
Water	5	*.*	BBL/D
Gas	15.0	*.*	Mscf/D
IPR Method			Vogel
Producing Efficiency			0.00%

Casing Pressure

Pressure	5.0 psi (g)

Annular Gas Flow

Gas Flow	5.8 Mscf/D

Fluid Properties

% Liquid Above Pump	77.13%
% Liquid Below Pump	*.*

Wellbore Pressures

PIP	99.4 psi (g) @ 7070 ft
PBHP	97.1 psi (g) @ 7063 ft
SBHP	*.*
Gas/Liq Interface	9.2 psi (g) @ 6729 ft

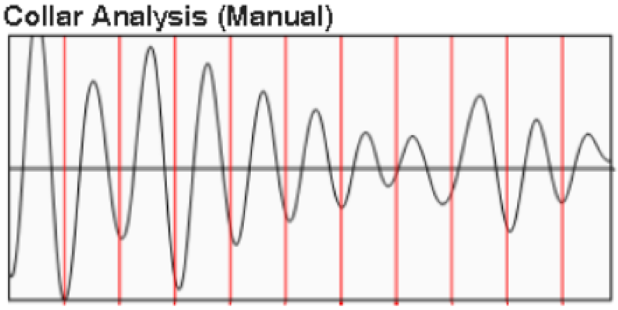
Depths

Pump Intake Depth	7070 ft
Formation Depth	7063 ft

Sensor Serial No.

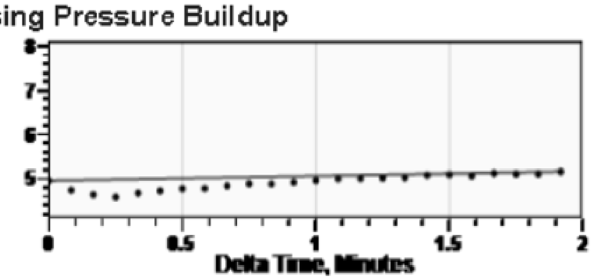
J SHOOTER (WRFG 220)

Collar Analysis (Manual)



Average Acoustic Velocity	1123 ft/s
Average Joints Per Sec.	17.89 Jts/sec
Joints To Liquid	214.29 Jts

Casing Pressure Buildup



Casing Pressure	5.0 psi (g)
Buildup	0.2 psi (g)
Buildup Time	1 min 55 sec
Gas Gravity	0.8719 Air = 1

Comments and Recommendations

SET ON HAND. AFTER BGC WAS INSTALLED

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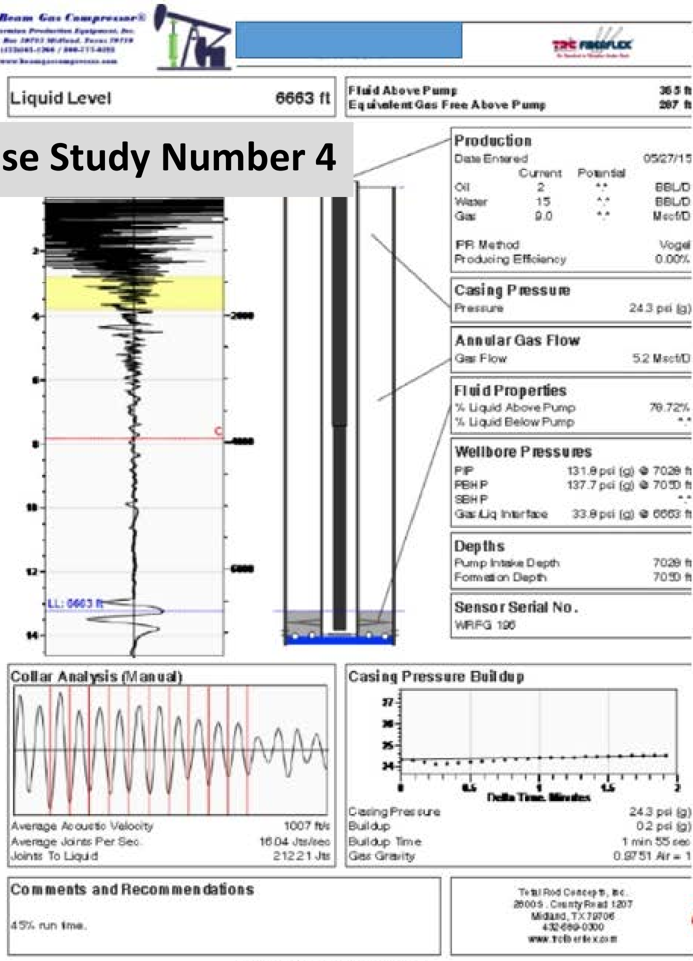
Case Study Number 4



The Beam Gas Compressor®

Liquid Level 6663 ft

Fluid Above Pump 365 ft
Equivalent Gas Free Above Pump 287 ft

Production
Date Entered 05/27/15

	Current	Potential	
Oil	2	*.*	BBL/D
Water	15	*.*	BBL/D
Gas	9.0	*.*	Mscf/D

IPR Method Vogel
Producing Efficiency 0.00%

Casing Pressure
Pressure 24.3 psi (g)

Annular Gas Flow
Gas Flow 5.2 Mscf/D

Fluid Properties
% Liquid Above Pump 78.72%
% Liquid Below Pump *.*

Wellbore Pressures
PIP 131.8 psi (g) @ 7028 ft
PBHP 137.7 psi (g) @ 7050 ft
SBHP *.*
Gas/Liq Interface 33.8 psi (g) @ 6663 ft

Depths
Pump Intake Depth 7028 ft
Formation Depth 7050 ft

Sensor Serial No.
WRFG 198

Collar Analysis (Manual)
Average Acoustic Velocity 1007 ft/s
Average Joints Per Sec. 16.04 Jts/sec
Joints To Liquid 212.21 Jts

Casing Pressure Buildup
Casing Pressure 24.3 psi (g)
Buildup 0.2 psi (g)
Buildup Time 1 min 55 sec
Gas Gravity 0.8751 Air = 1

Comments and Recommendations
45% run time.

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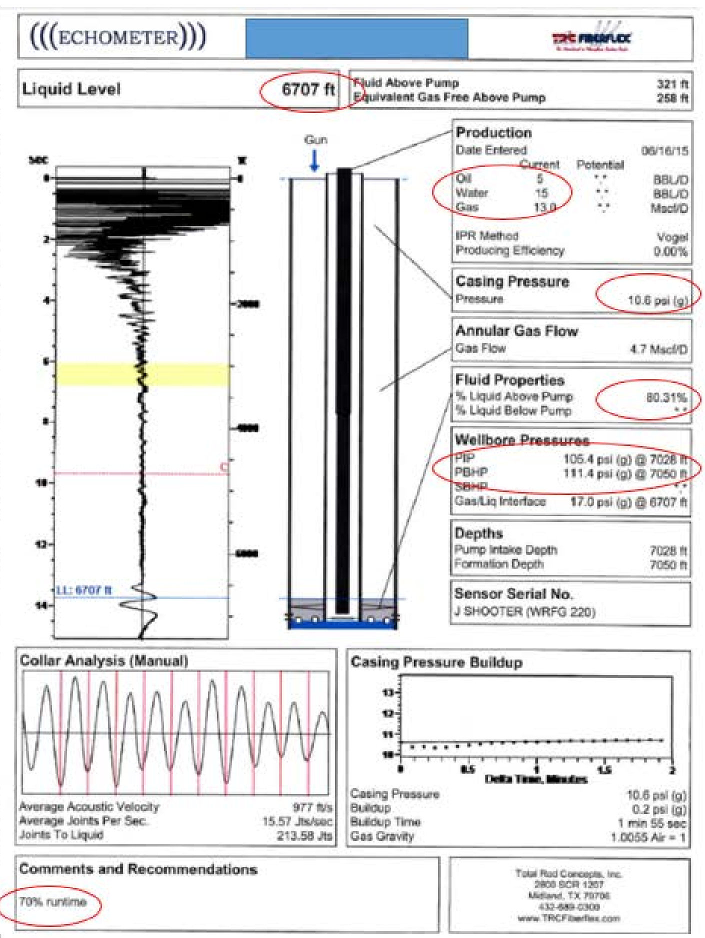
BEFORE BGC



(((ECHOMETER)))

Liquid Level 6707 ft

Fluid Above Pump 321 ft
Equivalent Gas Free Above Pump 258 ft

Production
Date Entered 06/16/15

	Current	Potential	
Oil	5	*.*	BBL/D
Water	15	*.*	BBL/D
Gas	13.0	*.*	Mscf/D

IPR Method Vogel
Producing Efficiency 0.00%

Casing Pressure
Pressure 10.6 psi (g)

Annular Gas Flow
Gas Flow 4.7 Mscf/D

Fluid Properties
% Liquid Above Pump 80.31%
% Liquid Below Pump *.*

Wellbore Pressures
PIP 105.4 psi (g) @ 7028 ft
PBHP 111.4 psi (g) @ 7050 ft
SBHP *.*
Gas/Liq Interface 17.0 psi (g) @ 6707 ft

Depths
Pump Intake Depth 7028 ft
Formation Depth 7050 ft

Sensor Serial No.
J SHOOTER (WRFG 220)

Collar Analysis (Manual)
Average Acoustic Velocity 977 ft/s
Average Joints Per Sec. 15.57 Jts/sec
Joints To Liquid 213.58 Jts

Casing Pressure Buildup
Casing Pressure 10.6 psi (g)
Buildup 0.2 psi (g)
Buildup Time 1 min 55 sec
Gas Gravity 1.0055 Air = 1

Comments and Recommendations
70% runtime

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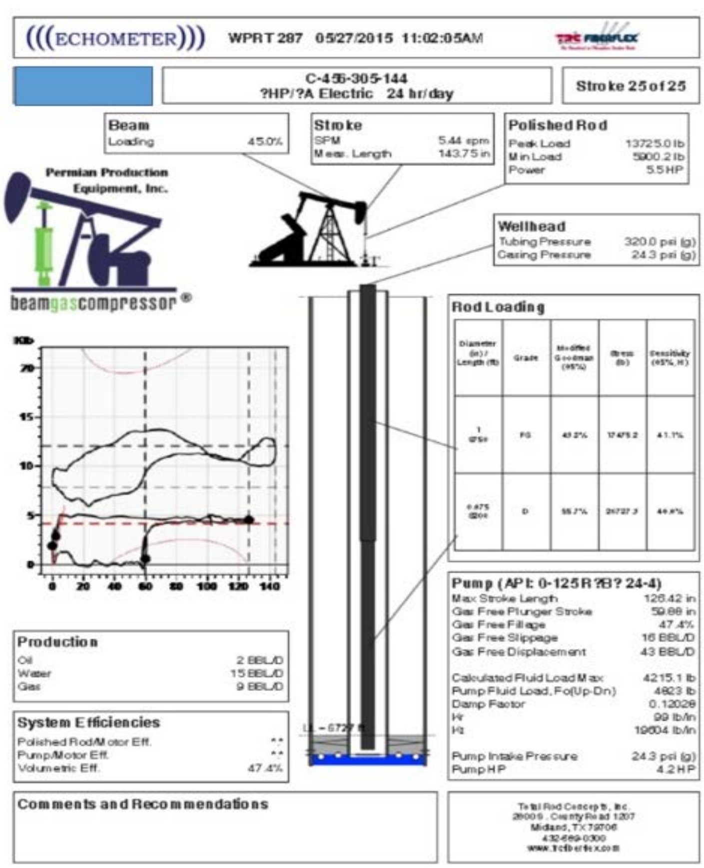
AFTER BGC



(((ECHOMETER))) WPRT 287 05/27/2015 11:02:05AM

C-456-305-144
?HP/?A Electric 24 hr/day

Stroke 25 of 25

Beam
Loading 45.0%

Stroke
SPM 5.44 spm
Meas. Length 143.75 in

Polished Rod
Peak Load 13725.0 lb
Min Load 5900.2 lb
Power 5.5 HP

Wellhead
Tubing Pressure 320.0 psi (g)
Casing Pressure 24.3 psi (g)

Permian Production Equipment, Inc.
beamgascompressor®

Rod Loading

Pump (API: 0-125 R?B? 24-4)
Max Stroke Length 126.42 in
Gas Free Plunger Stroke 59.88 in
Gas Free Fillage 47.4%
Gas Free Slippage 16 BBL/D
Gas Free Displacement 43 BBL/D

Calculated Fluid Load Max 4215.1 lb
Pump Fluid Load, Fo(Up-Dn) 4823 lb
Damp Factor 0.12026
Kr 99 lb/in
Kt 19604 lb/in

Pump Intake Pressure 24.3 psi (g)
Pump HP 4.2 HP

Production
Oil 2 BBL/D
Water 15 BBL/D
Gas 9 BBL/D

System Efficiencies
Polished Rod/Motor Eff. *.*
Pump/Motor Eff. *.*
Volumetric Eff. 47.4%

Comments and Recommendations

Total Rod Concepts, Inc.
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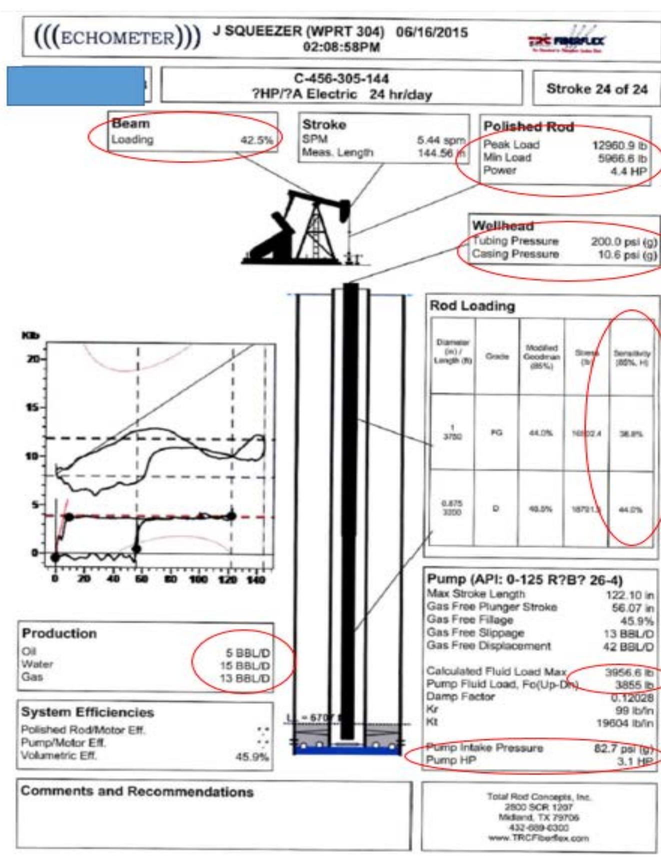
BEFORE BGC



(((ECHOMETER))) J SQUEEZER (WPRT 304) 06/16/2015 02:08:58PM

C-456-305-144
?HP/?A Electric 24 hr/day

Stroke 24 of 24

Beam
Loading 42.5%

Stroke
SPM 5.44 spm
Meas. Length 144.56 in

Polished Rod
Peak Load 12960.9 lb
Min Load 5966.6 lb
Power 4.4 HP

Wellhead
Tubing Pressure 200.0 psi (g)
Casing Pressure 10.6 psi (g)

Rod Loading

Pump (API: 0-125 R?B? 26-4)
Max Stroke Length 122.10 in
Gas Free Plunger Stroke 56.07 in
Gas Free Fillage 45.9%
Gas Free Slippage 13 BBL/D
Gas Free Displacement 42 BBL/D

Calculated Fluid Load Max 3956.6 lb
Pump Fluid Load, Fo(Up-Dn) 3855 lb
Damp Factor 0.12028
Kr 99 lb/in
Kt 19604 lb/in

Pump Intake Pressure 82.7 psi (g)
Pump HP 3.1 HP

Production
Oil 5 BBL/D
Water 15 BBL/D
Gas 13 BBL/D

System Efficiencies
Polished Rod/Motor Eff. *.*
Pump/Motor Eff. *.*
Volumetric Eff. 45.9%

Comments and Recommendations

Total Rod Concepts, Inc.
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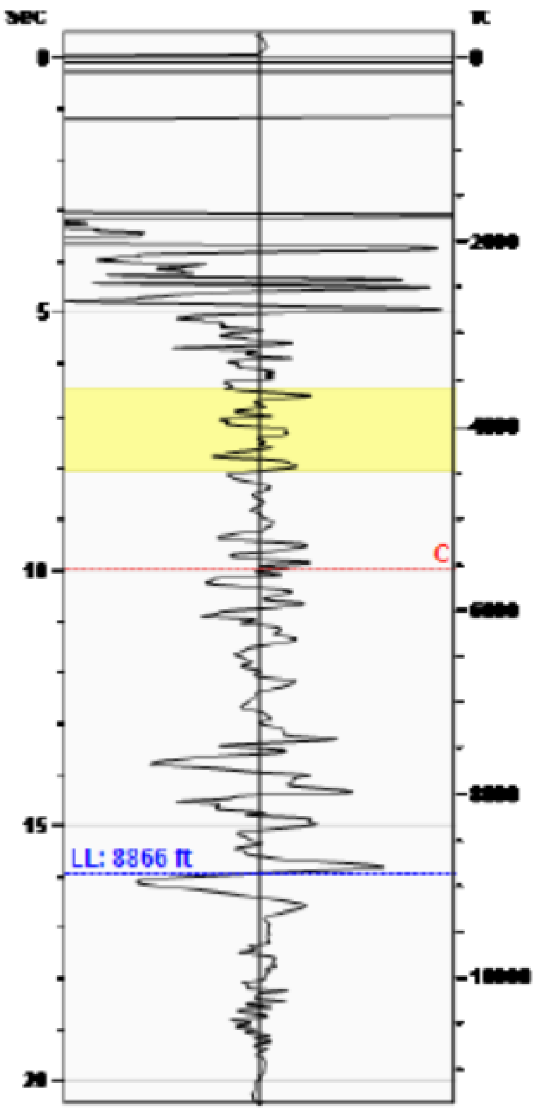
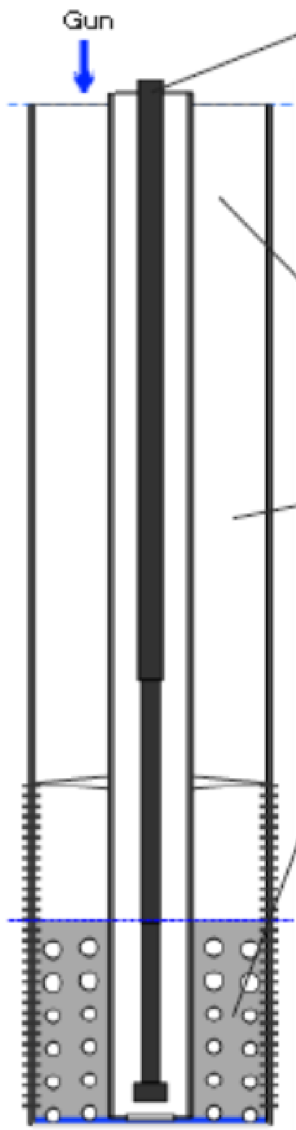
AFTER BGC

Liquid Level	8866 ft

Fluid Above Pump	2152 ft
Equivalent Gas Free Above Pump	662 ft

Case Study Number 5





Production

Date Entered			12/01/14
	Current	Potential	
Oil	20	*.*	BBL/D
Water	40	*.*	BBL/D
Gas	60.0	*.*	Mscf/D
IPR Method			Vogel
Producing Efficiency			0.00%

Casing Pressure

Pressure 34.2 psi (g)

Annular Gas Flow

Gas Flow 39.2 Mscf/D

Fluid Properties

% Liquid Above Pump	29.50%
% Liquid Below Pump	*.*

Wellbore Pressures

PIP	272.7 psi (g) @ 11018 ft
PBHP	260.0 psi (g) @ 10980 ft
SBHP	0.0 psi (g) @ 10980 ft
Gas/Liq Interface	48.8 psi (g) @ 8866 ft

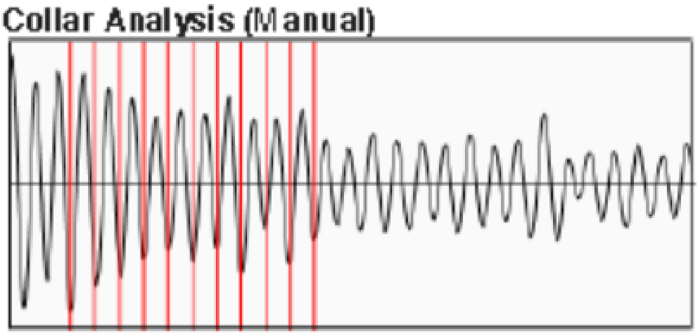
Depths

Pump Intake Depth	11018 ft
Formation Depth	10980 ft

Sensor Serial No.

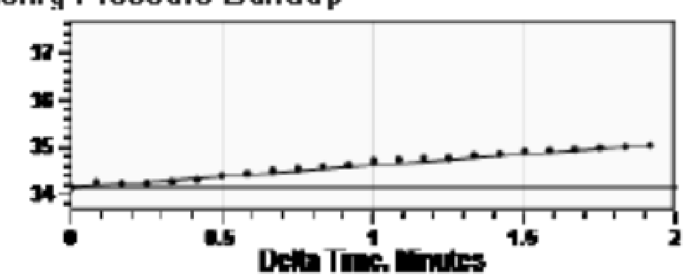
WRFG 196

Collar Analysis (Manual)



Average Acoustic Velocity	1113 ft/s
Average Joints Per Sec.	17.55 Jts/sec
Joints To Liquid	279.69 Jts

Casing Pressure Buildup



Casing Pressure	34.2 psi (g)
Buildup	0.9 psi (g)
Buildup Time	1 min 55 sec
Gas Gravity	0.8718 Air = 1

Comments and Recommendations

45% RUN TIME. BEFORE BGC WAS INSTALLED

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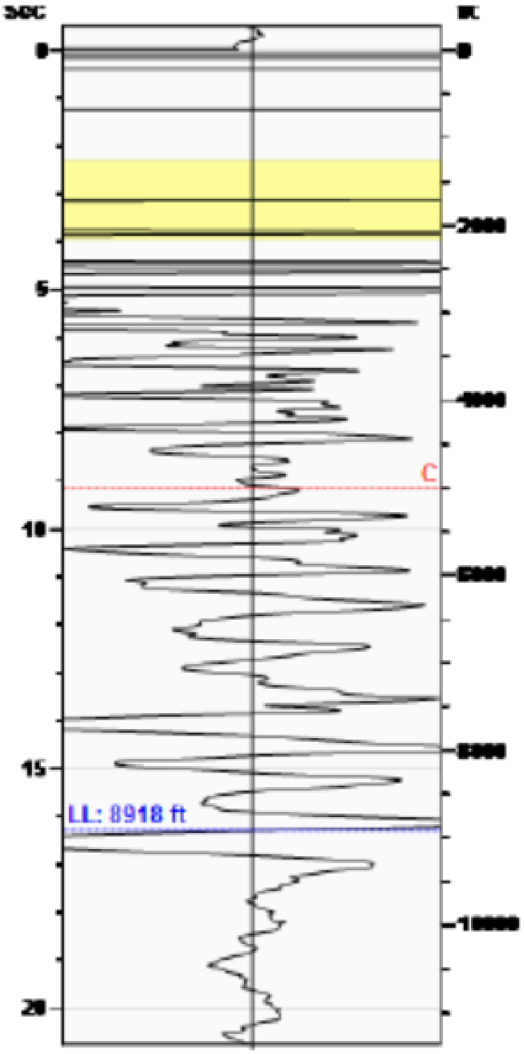
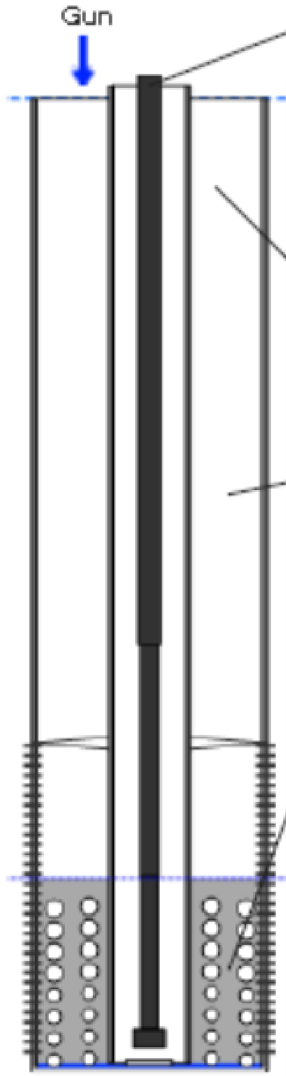
Liquid Level	8918 ft

Fluid Above Pump	2100 ft
Equivalent Gas Free Above Pump	538 ft

Case Study Number 5





Production

Date Entered			12/19/15
	Current	Potential	
Oil	35	*.*	BBL/D
Water	45	*.*	BBL/D
Gas	98.0	*.*	M scf/D
IPR Method			Vogel
Producing Efficiency			0.00%

Casing Pressure

Pressure	10.5 psi (g)

Annular Gas Flow

Gas Flow	91.1 M scf/D

Fluid Properties

% Liquid Above Pump	24.26%
% Liquid Below Pump	*.*

Wellbore Pressures

PIP	201.4 psi (g) @ 11018 ft
PBHP	188.6 psi (g) @ 10980 ft
SBHP	0.0 psi (g) @ 10980 ft
Gas/Liq Interface	18.2 psi (g) @ 8918 ft

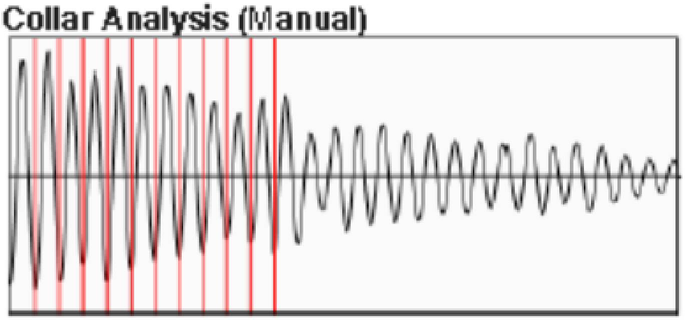
Depths

Pump Intake Depth	11018 ft
Formation Depth	10980 ft

Sensor Serial No.

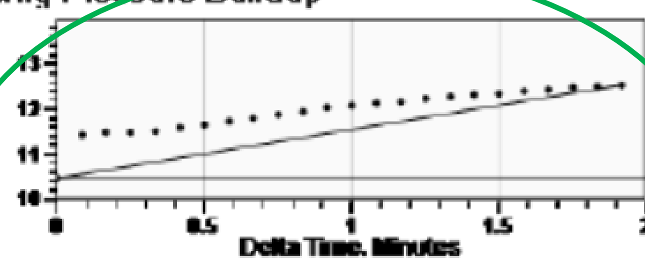
J SHOOTER (WRFG 220)

Collar Analysis (Manual)



Average Acoustic Velocity	1094 ft/s
Average Joints Per Sec.	17.26 Jts/sec
Joints To Liquid	281.32 Jts

Casing Pressure Buildup



Casing Pressure	10.5 psi (g)
Buildup	2.1 psi (g)
Buildup Time	1 min 55 sec
Gas Gravity	0.8831 Air = 1

Comments and Recommendations

90% run time. AFTER BGC installed

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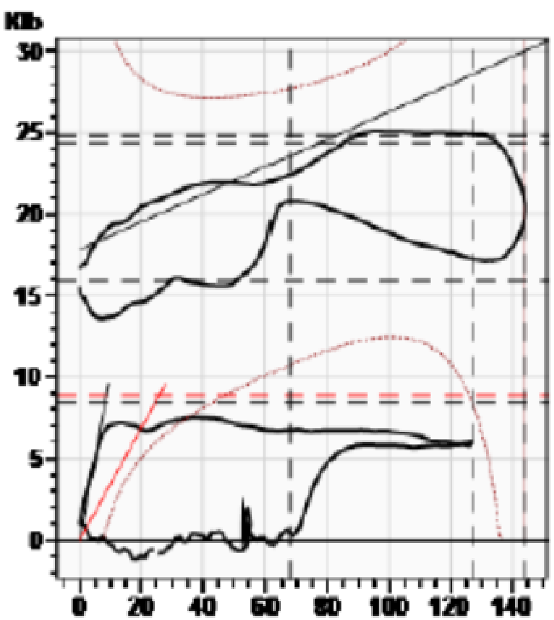
Case Study Number 6

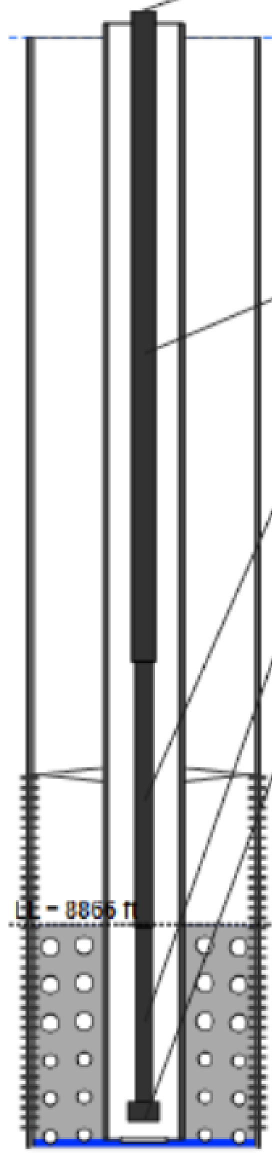
Beam
Loading 68.8%

Stroke
SPM 7.38 spm
Meas. Length 144.00 in

Polished Rod
Peak Load 25112.9 lb
Min Load 13615.0 lb
Power 14.2 HP

Well head
Tubing Pressure 28.4 psi (g)
Casing Pressure 34.2 psi (g)





Rod Loading

Diameter (in) / Length (ft)	Grade	Modified Goodman (85%)	Stress (lb)	Sensitivity (85%, H)
1.25 6287	FG	51.6%	20468.8	49.2%
1 2650	D	69.7%	25334.3	61.2%
0.875 1750	D	72.7%	21020.5	51.8%
1.625 200	SB	22.5%	4416.4	10.4%

Pump (API: 25-150 R ?B? 0-4)
Max Stroke Length 126.72 in
Gas Free Plunger Stroke 67.71 in
Gas Free Fillage 53.4%
Gas Free Slippage 21 BBL/D
Gas Free Displacement 110 BBL/D

Calculated Fluid Load Max 8909.3 lb
Pump Fluid Load, Fo(Up-Dn) 6788 lb
Damp Up 0.16018 Damp Dn 0.16018
Kr 91 lb/in
Kt 1202 lb/in

Pump Intake Pressure 1200.4 psi (g)
Pump HP 10.3 HP

Production
Oil *.* BBL/D
Water *.* BBL/D
Gas *.* BBL/D

System Efficiencies
Polished Rod/Motor Eff. *.*
Pump/Motor Eff. *.*
Volumetric Eff. 53.4%

Comments and Recommendations

45% RUN TIME. BEFORE BGC WAS INSTALLED

20 Oil BPD
30 Water BPD
50 Gas MCFD

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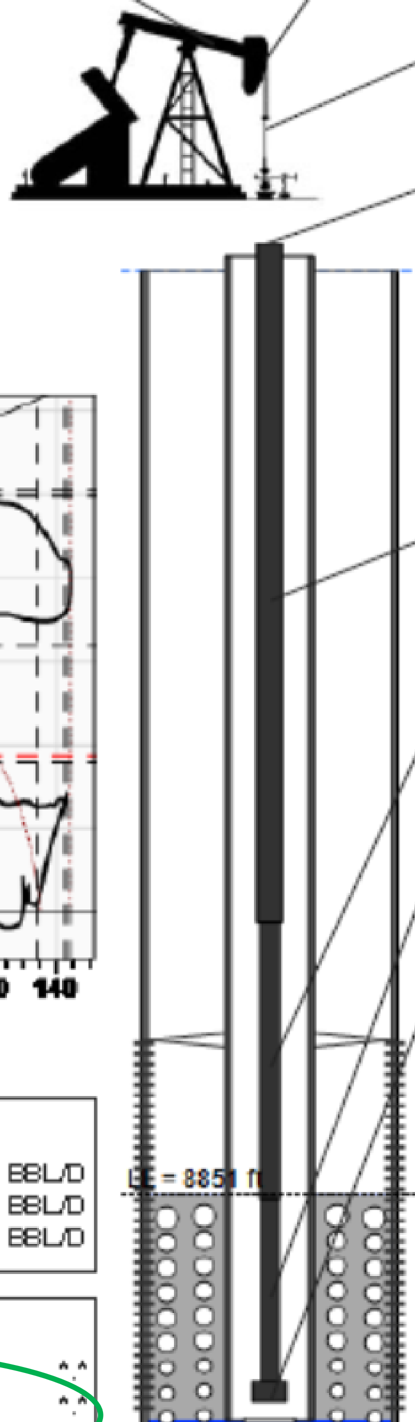
Beam
Loading 68.6%

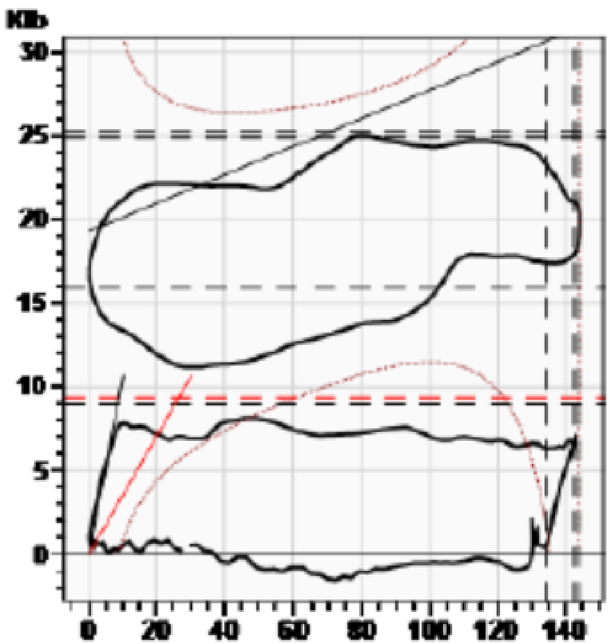
Stroke
SPM 7.32 spm
Meas. Length 144.00 in

Polished Rod
Peak Load 25043.2 lb
Min Load 11206.8 lb
Power 23.5HP

Case Study Number 6



Wellhead
Tubing Pressure 281.8 psi (g)
Casing Pressure 20.6 psi (g)



Rod Loading

Diameter (in) / Length (ft)	Grade	Modified Goodman (85%)	Stress (lb)	Sensitivity (85%, H)
1.25 / 6287	FG	57.4%	20407.0	49.0%
1 / 2650	D	74.9%	26288.4	61.7%
0.875 / 1750	D	81.5%	28053.1	54.8%
1.625 / 200	SB	25.8%	4787.9	11.1%

Production
Oil *.* BBL/D
Water *.* BBL/D
Gas *.* BBL/D

Pump (API: 25-150 R ?B? 0-4)
Max Stroke Length 142.32 in
Gas Free Plunger Stroke 134.17 in
Gas Free Fillage 94.3%
Gas Free Slippage 23 BBL/D
Gas Free Displacement 235 BBL/D

Calculated Fluid Load Max 9357.0 lb
Pump Fluid Load, Fo(Up-Dn) 7237 lb
Damp Up 0.16018 Damp Dn 0.16018
Kr 91 lb/in
Kt 1202 lb/in

Pump Intake Pressure 1199.8 psi (g)
Pump HP 18.9 HP

System Efficiencies
Polished Rod/Motor Eff. *.*
Pump/Motor Eff. *.*
Volumetric Eff. 94.3%

Comments and Recommendations

90% RUN TIME. AFTER BGC WAS INSTALLED

45 Oil BPD
50 Water BPD
10 0 Gas MCFD

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[i] **Analyzing Well Performance 98**
A. L. Podio, University of Texas at Austin
J. N. McCoy, Doug Cook and Dieter Becker, Echometer Company

[ii] **Improving Oil and Gas Production with the Beam Mounted Gas Compressor**
Ali Al-Khatib, Mobil Oil Company, SPE.