GAS WELL DELIQUIFICATION USING C-25 & C-40 PUMPING UNITS

Cody Pye
BP America

ABSTRACT

Higher gas prices have presented new opportunities in gas fields but an imperative issue throughout these fields is liquid loading. This paper discusses and presents results from a low rate, low cost deliquification project. Small, low cost C-25 and C-40 pumping units with small motors and small diameter pumps were installed to keep water off the formation, enabling the production of gas. This is a long term solution allowing the well to produce to its economic limit in an efficient, low maintenance system.

INTRODUCTION

As gas fields mature, liquid loading becomes a critical concern. Every field and well is unique requiring different artificial lift methods. Rod pumps have been around for many years and have become a West Texas standard to deliquify oil wells. The application of small, low rate rod pumps to unload gas wells is a natural extension and ahs proven to be a successful application.

The Block 31 field is northwest of Crane, Texas and possesses wells producing from the Queen horizon. The Queen formation is approximately 3,000' deep (above the Grayburg formation) and produces low volumes of gas and water. These wells produce 45-100 mcf/day and 3-5 bwpd must be removed to prevent liquid loading unless the well was fraced in which case fluid production can average about 14 bfpd.

FORMATION & WELLBORE

There are two types of wellbores producing from the Queen formation; those which were recompleted from the Devonian to the Queen, and those originally drilled as Queen wells. Those drilled as Queen wells were completed in 1998 with 4 ½" 9.5# production casing, 2 3/8" tubing, and about fifteen feet of pay (~2916-2932) with an average plug back depth of 2998'. The recompleted wellbores have 5 ½" 15.5# and 17# casing with 2 7/8" tubing, about thirteen feet of pay (~2959-2972), and an average plug back depth of 8432'. The biggest difference between these two wellbores is the PBTD and available rat hole. This is important due to the location of the pump, which will be further discussed.

PUMP INFORMATION

A pump capable of handling 100% water (ie no lubrication) was installed in these wells and was specifically designed for this application with the help of Harbison Fischer. The pump is a 20-106-RHBC-8-40 Flexite Ring with a pump clearance of .003" (.002 on plunger and .001 on the barrel). The pump barrel is a carbon steel, Harbison-Fischer Tuff-Temper which have a hard, wear-resistant surface that withstands abrasion and sand, scale and mild corrosion. The carbon steel barrel has a Rockwell C hardness from 48 to 52. The 1 1/16" pump is more than capable of pumping the required load to deliquify these gas wells. At 10 spm, the 1 1/16" pump has a capacity of approximately 16 bfpd. As mentioned these wells only produce a max rate of 5 bfpd. However, if the well was fractured into the lower Grayburg zone, a max rate up to 15 bfpd can be expected. The pump is designed to handle either scenario. Due to the low rate and high-water cut production, flexite rings are installed on the plunger to expand on the up-stroke and gradually decrease on the down stroke to provide lubrication. A significant design issue of this pump was discovered following pump failures. The original pump configuration was single valved, but solids or paraffin were preventing a reliable seal due to the size of the valves. This problem was solved by double valving both the traveling and standing valves to enable the first valve to collect the film or trash and allow the second valve to create a seal. This is an inexpensive solution to ensure a longer pump life.

The pump location within the wellbore is important to the success of this design to enable the liquid and gas to naturally separate within the wellbore. The wells drilled only for the Queen formation have a limitted amount of rat hole, so the pump is set as close to PBTD as possible. The recompleted Queen wellbores have hundreds of feet of rat hole so the pump is set ~100' below the bottom perf. In a couple of wells, the pump was initially set 20-50' below the bottom perf, the pump was lowered to 100’ below the lower perf on the first workover to improve efficiency.

PUMPING UNIT DESIGN

A small pumping unit is sufficient to produce the required low volume. A conventional API 25 unit is preferred, however surplus availability was an issue so some conventional API 40 units were also utilized.

Every unit is operated in the short hole. This results in a surface stroke length of about 20” with a downhole stroke length of about 15” for the C25’s. For the larger C40 units the pump stroke was 24” with a downhole stroke length of 24”. Depending on the strokes per minute, the capacity with a 1 1/16” pump range from 13-33 bfpd for the C25 units and 13-46 bfpd for C40 units. These units are structurally capable of operating at 8 to 20 strokes per minute with these conditions. Initially, the units were run at 8 spm, but the wells were not pumping well. It was determined that due to the short stroke length the units should be sped up to ensure the traveling and standing balls seat. Therefore, the units were sped up to 10 spm, which solved the problem.

Due to the shallow depth and low volume, the polish rod load required is minimal. However, it is important to note that a C25-43-30” unit is not applicable for these wells due to the 4,300 lb structure capacity. If applied to these wells the unit would be overloaded and therefore improperly designed. Thus the smallest C25 installed was a C25-53-24”. For the C25 units the theoretical polish rod load ranged from 5,300-6,700 lbs and 5,600-8,900 lbs for the C40 units. When the C25 units are operated at 10 spm the measured PPRL is 4,700 lbs and MPRL is 2,200lbs (well within the limits of the C25-53-24” units installed). One surprising point for these units is the polish rod horsepower. At 10 spm the PRHP does not exceed 1 hp for both units. Although the max horsepower is 1 hp, we opted to install 5 hp motors due to the versatility and popularity of these motors.

The gearbox loading for both units is far removed from the max limit. The C25 units gearbox loading does not exceed 60% at 10 spm with a peak torque of ~13,000 in-lbs. Similar to the C25, the C40 units gearbox loading does not exceed 50% at 10 spm with a peak torque of ~14,000 in-lbs. The C40 units are oversized for this application, however as stated the availability of C25 units was the issue.

The rod size was limited for the C25 units to 5/8” rods as the units would be overloaded with the heavier ¾” rods. While**,** the 5/8” rod loading never exceeded 50% at 10 spm. The wells with C40 units had the option to install ¾” or 5/8” rods. Using either size did not yield a rod loading that exceeded 50%. For the C40 units, the availability of the rods typically determined which is installed. The ¾” rods are more common, heavier and easier to handle. However, the 5/8” rods are cheaper and more than capable of handling the load.

Pump off controllers are not installed on these wells due to economics. Percentage timers are installed and operated from a PLC. Due to a fear of over-pumping the units, the timers were set using the fluid level from the top down. This meant running the unit at a low percent with a high fluid level initially. As the run time percentage was increased, the fluid level decreased and eventually the exact timer percentage was obtained. This optimization relies heavily on the pumper and the fluid level readings. The prior method was to start the timer at 100% until the well was pumped off and then decrease the timer. The issue with this method is over-pumping the small pump and causing a pre-mature failure.

PROBLEMS

There are few problems and issues with this deliquification design. One minor issue for a few of the originally drilled Queen wells was that the perforations were covered due to fill with frac sand from the initial completion. The wells had not been worked over since they were drilled in the late 90’s so this problem was solved by using a hydrostatic bailer to remove the sand.

The most critical problems encountered were paraffin, iron sulfide and asphaltines which caused numerous premature pump failures. Iron sulfide was easily removed by acidizing each well prior to rigging up. The paraffin and asphaltene issue was not as easy to resolve. The most effective treatment was designed after lab analyses of samples and dissolution with various chemicals. The wells were treated during initial work and receive a weekly solvent flush to remove asphaltines after which the well is circulated for a few hours or overnight allowing the solvent to dissolve and move the paraffin and asphaltines. It is important to maintain a chemical program to ensure the paraffin problems are minimized.

RECOMMENDATIONS AND CONCLUSIONS

- No POC therefore manage fluid level from top down to prevent over pumping and accurately set timer
- Run a 1 1/16" pump w/ flexite ring plunger
- Set pump below perfs or as close to PBTD as possible
- Set unit in short stroke
- Run unit at ~10 spm to increase ball/seat action
- This is a long term solution allowing the well to produce to its economic limit in an efficient, low maintenance system.
- Production prior to project ~700 MCFPD. Production to date ~1,000 MCFPD. Goal is 1,200 MCFPD

Table 1
Conventional 25 Pumping Unit Results

Unit	SPM	Capacity	Calculated stroke length	Gross Pump Stroke	PPRL	MPRL	PRHP	PT	Gearbox loading	Rod Size	Rod Loading
	strokes/min	bfpd	in	in	C lbs	C lbs	HP	M in-lbs	%	in	%
C25-53-24	8	13	20	15	45	23	0.5	11	45	5/8	41
	10	16	20	16	47	22	0.7	13	50	5/8	45
	20	33	20	16	51	17	1.5	17	68	5/8	60
C25-67-36	8	13	20	15	46	23	0.5	13	51	5/8	42
	10	16	20	15	48	22	0.7	14	56	5/8	46
	20	33	20	16	52	18	1.5	17	69	5/8	60

Table 2
Conventional 40 Pumping Unit Results

Unit	SPM	Capacity	Calculated stroke length	Gross Pump Stroke	PPRL	MPRL	PRHP	PT	Gearbox loading	Rod Size	Rod Loading
	strokes/min	bfpd	in	in	C lbs	C lbs	HP	M in-lbs	%	in	%
C40-56-36	8	13	20	15	46	23	0.5	13	32	5/8	42
	10	16	20	15	48	22	0.7	14	35	5/8	46
	20	33	20	16	52	18	1.5	17	43	5/8	60
C40-89-42	8	17	24	20	61	35	0.8	18	44	3/4	34
	10	22	24	21	63	33	1	20	49	3/4	39
	20	46	24	22	69	26	2.2	27	66	3/4	53

Figure 1 - National C25-65-24" Pumping Unit

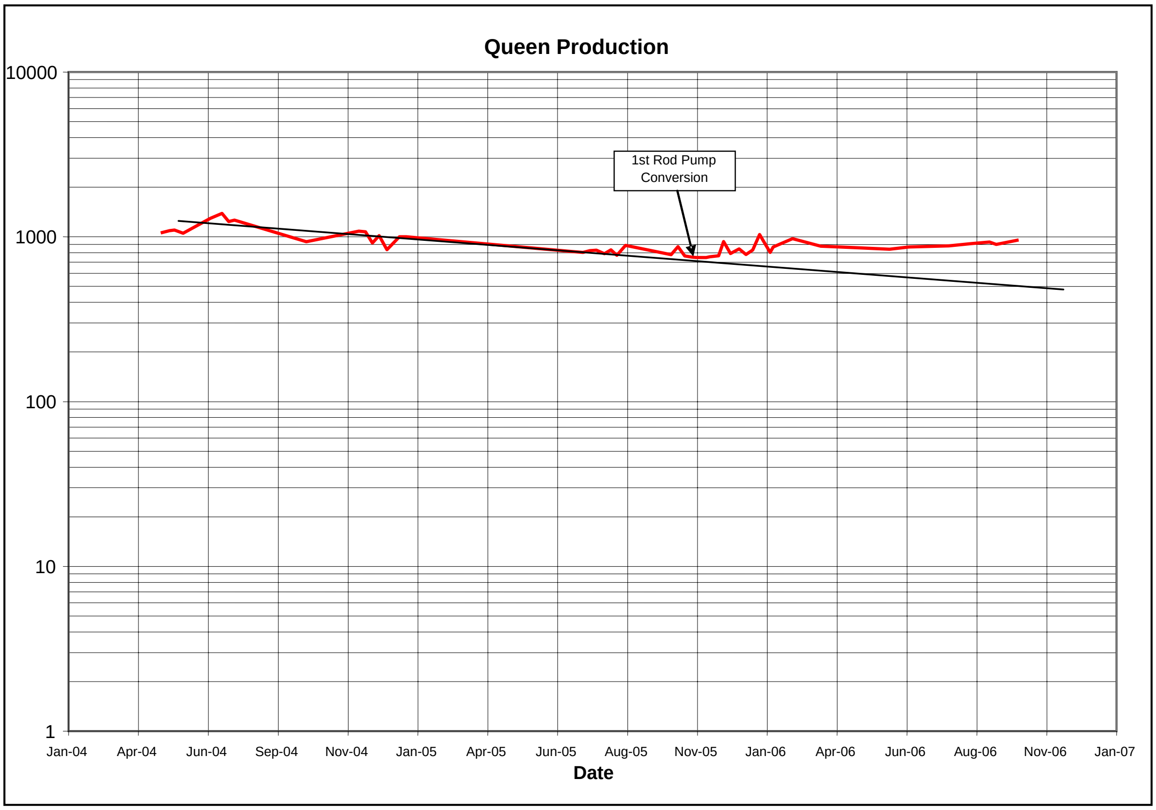

Figure 2 - Block 31 Queen Production