Go Technologies Blower Pilot

Project Performance Evaluation Report

Revision 2.0

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Prepared by

Nathan King

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1 Executive Summary

This report documents the Go Technologies Blower Pilot 2015-2016. The research, design, execution, and results of the pilot are described in this report.

The Bonnyville/Lloydminster district currently uses reciprocating compressors. These units are often used outside of their intended operating conditions. This creates operational upsets, ineffective casing gas capture and increased venting of methane. The Go Technologies Blower Compressor is capable of handling higher volumes of casing gas while achieving a lower outlet pressure. The purpose of the pilot is to determine if the blower compressors can achieve the following: decrease site emissions by effectively capturing vented methane, optimize equipment fuel use, increase oil production by drawing down casing gas pressure, and decrease maintenance requirements of casing gas equipment.

The key performance indicators (KPIs) for this project included vent volumes prior to and post installation, site fuel use, production over the 9 month piloting period and maintenance conducted on the Go Technologies blower compressor.

An experimental test plan was developed and then executed successfully resulting in stable operation of the compressors on two well pad sites. The reduced maintenance objective of the pilot was met however measurement of reduced vent volumes, efficient fuel use and increased oil production was inconclusive due to gas production characteristics and limited measurement capabilities in the Lloydminster district.

After completion of the pilot, the recommendation is to continue to monitor the blower compressors currently in place and possibly find alternative sites that would see a greater benefit from these units. Compressor evaluation has been seriously limited by gas measurement techniques currently employed in Bonnyville and Lloydminster. To support additional casing gas technology piloting these districts would benefit greatly from advancement in gas measurement technology. In the meantime it is recommended that the Bonnyville/Lloydminster district utilize the existing compressors designs on a case by case basis at the discretion of field staff.

2 Project Introduction

2.1 Background

Go Technologies has developed a high volume blower compressor that is suitable to deal with the high volume, low pressure casing gas systems in the Bonnyville/Lloydminster district. Lloydminster operations selected the following wellsites to pilot the compressors: 100/11A-03-49-05W4, 102/5C2-30-48-05W4 and 103/5D-30-48-05W4.

2.2 Pilot Objectives

The Go Technologies Blower Pilot was proposed in the Lloydminster district with the following pad site scenarios identified:

1. Back pressure sensitivity, low suction pressure and high vent
2. Back pressure sensitivity, low suction pressure and high propane use
3. Extreme backpressure sensitivity requiring vacuum to produce

During the pilot, every effort was made to keep the compressors running continuously. Methane venting, fuel use and production were monitored throughout. Operations staff were also consulted to assess maintenance requirements of the units.

2.3 Definition of Success

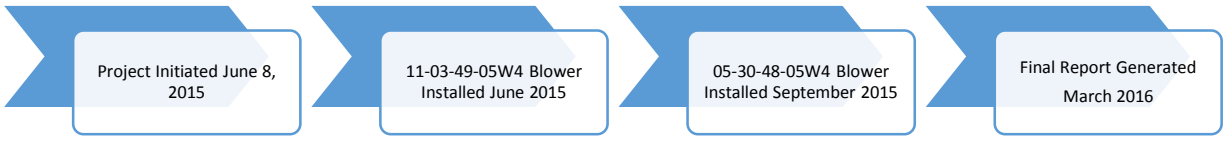
The Go Technologies Blower project can be declared successful on demonstration of the following:

- Decreased methane vent volumes post blower compressor installation
- Increased fuel consumption by each site while eliminating propane use
- Increased oil production by eliminating casing gas back pressure
- Decreased maintenance conducted

2.4 Schedule

The Go Technologies Blower Pilot was initiated on June 8, 2015. The first blower was installed on location 11-03-49-05W4 in June 2015. The second blower was installed on location 05-30-48-05W4 in September, 2015. The third blower compressor is currently being examined by Devon Bonnyville Operations, however, data from this compressor could not be obtained within the period of this pilot.

Figure 1 - Project Timeline



2.5 Variables Measured

Throughout the pilot the following parameters were measured and recorded for comparison:

- Methane vent volumes prior to and post installation (e3m3/day)
- Fuel used by each site (e3m3/month)
- Production over the past 9 months (m3/day)
- Maintenance conducted

2.6 Pilot Test Procedure

Operations found it necessary to deviate from the pilot plan in one instance. Site behavior and maintenance recommendations caused the original locations to be changed. Operations staff chose the two pad sites 11-03-49-05W4 and 05-30-48-05W4 for piloting the compressors. The locations reviewed in this report were chosen due to their ability to more accurately evaluate the project KPIs. The rest of the pilot plan was followed in order to accurately rate the performance of the Go Technologies blower compressor.

3 Execution

This section is meant to capture some of the best practices that resulted from the execution phase of the Go Technologies Blower Pilot. The intention is that these practices can be applied in future implementation of compressor technology.

Prior to compressor installation Lloydminster operations personnel were consulted to determine the best course of action when piloting this technology. The successful execution of this pilot was therefore left to the attention of the maintenance and operations staff in the Lloydminster field.

3.1 Installation

Installation required a few hours during June and September 2015, to retrofit existing casing gas systems with each new blower compressor. This was led by the Lloydminster maintenance group. Installation of the compressors took place without sacrificing operational efficiency and no upsets in production were observed. Compressor specifications can be found in Appendix A.

3.2 Pilot Operation

The pilot was conducted within a 9 month period. During this period both blower units were installed, KPI data was monitored and updates were provided by operators to provide clarity on how the equipment was functioning.

During initial operation of the compressors automated high and low set-points required several iterations of adjustments to avoid unwanted shutdowns. Adjustment of the unit's temperature control was also necessary to allow the equipment to run at higher temperatures. However, once these two alterations were made the units reportedly ran well throughout the pilot. No casing gas system upsets were observed and operators found the operation of the units straightforward without putting an additional workload on operations staff.

4 Results

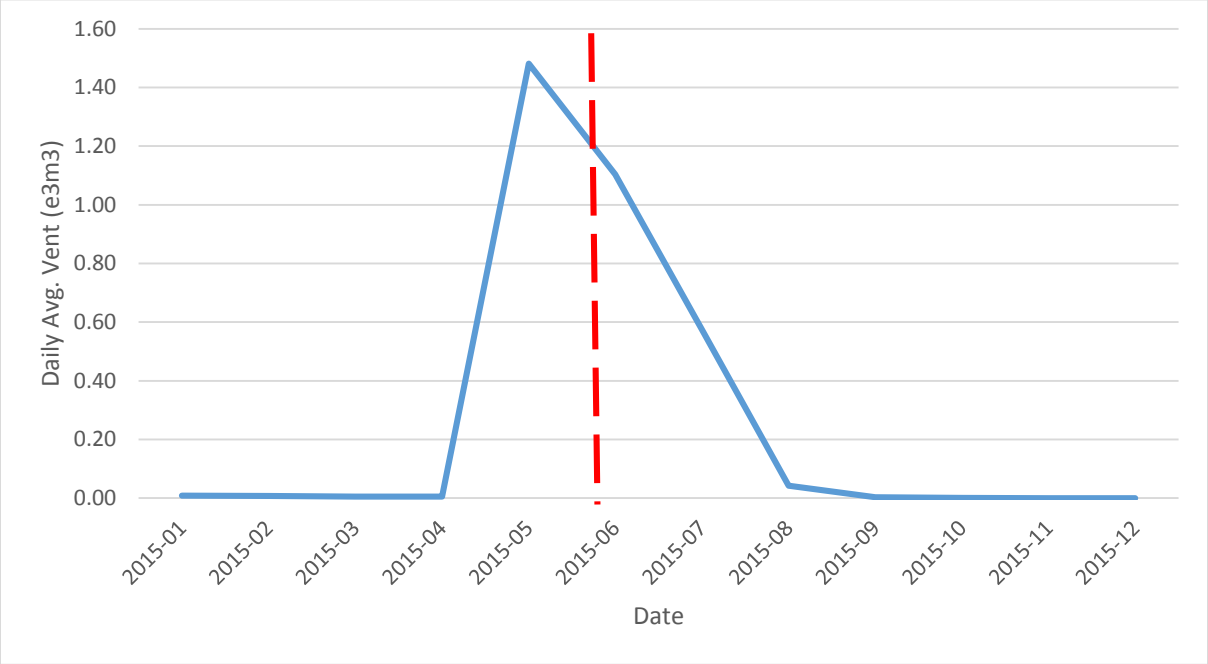
The operational results of the pilot are summarized in this section including the following KPIs:

- Vent volumes prior to and post blower compressor installation (e3m3/day)
- Changes in site fuel usage (e3m3/month)
- Production information over the past 9 months (m3/day)
- Maintenance conducted on site casing gas systems

4.1 Venting Information

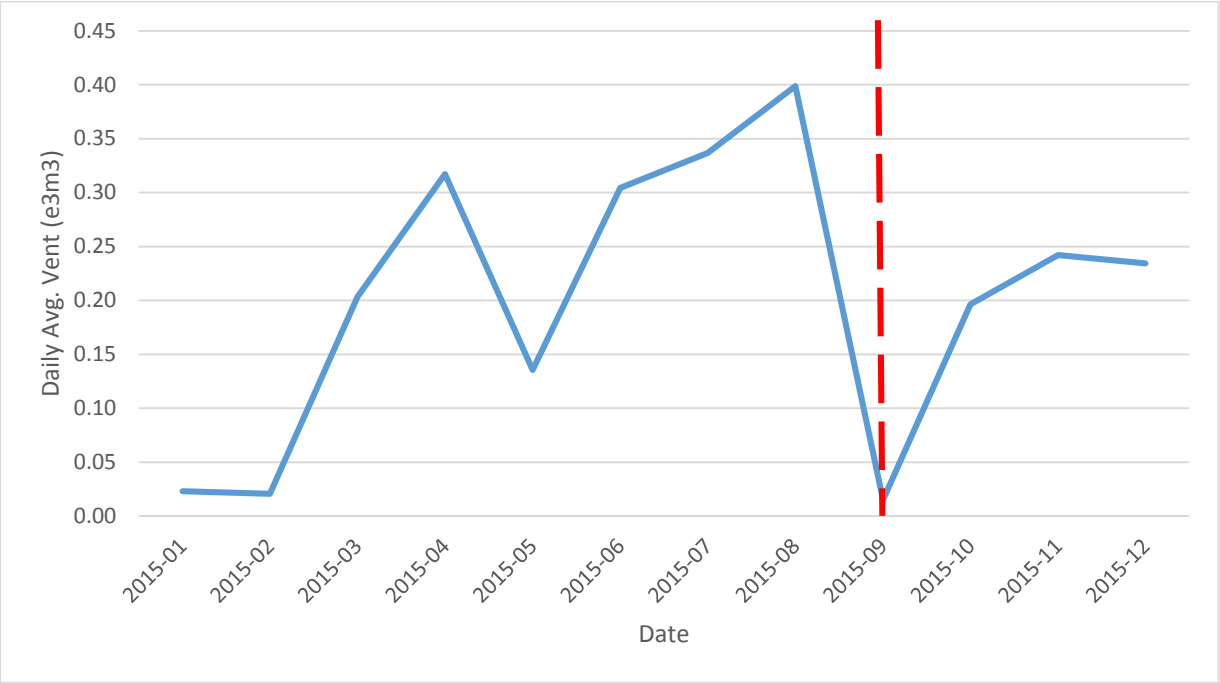
Venting data for each blower installation site can be seen in Figure 2 and Figure 3. The dashed line indicates the timing of the compressor's installation.

Figure 2 - 11-03-49-05W4 Daily Vent Volumes



The vent volume spike seen in Figure 2 is due to existing compressor malfunction on the 11-03-49-05W4 site prior to piloting the Go Technologies compressor. Venting on the site is eliminated as the blower compressor is installed in June, 2015, and adequate set-point are established by September, 2015.

Figure 3 – 5-30-48-05W4 Daily Vent Volumes



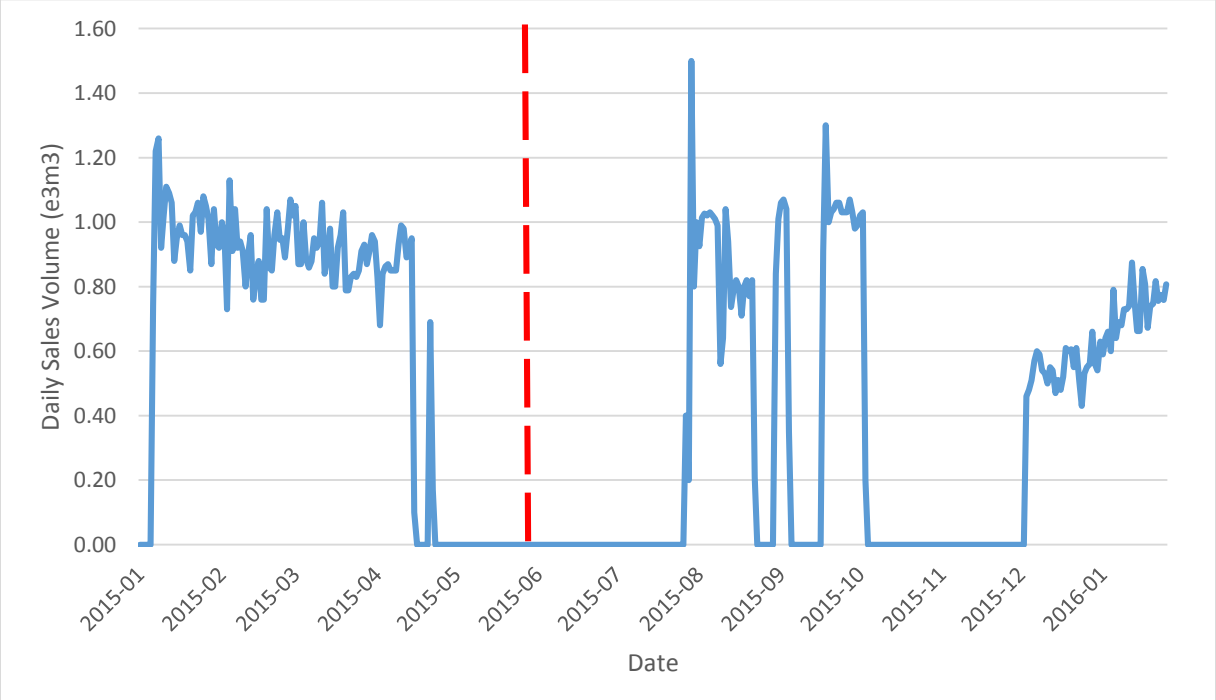
Venting on the 5-30-48-05 pad is highly variable throughout 2015. The blower was unable to eliminate all venting on this site following its September, 2015 installation. The ability of the blower compressor to eliminate venting is therefore inconclusive due to the high variability in the vent volumes measured on each site. This is due to a combination of changing gas volumes produced by a CHOPS wells on a daily basis and the inability to accurately measure these changes.

4.2 Site Fuel Use

Fuel volumes for each site can be seen in Figure 4 and Figure 6. The 11-03-49-05W4 site is also tied into sales. The 2015 sales volumes from this site can be seen in Figure 5. Again, the dashed line indicates the timing of the compressor's installation.

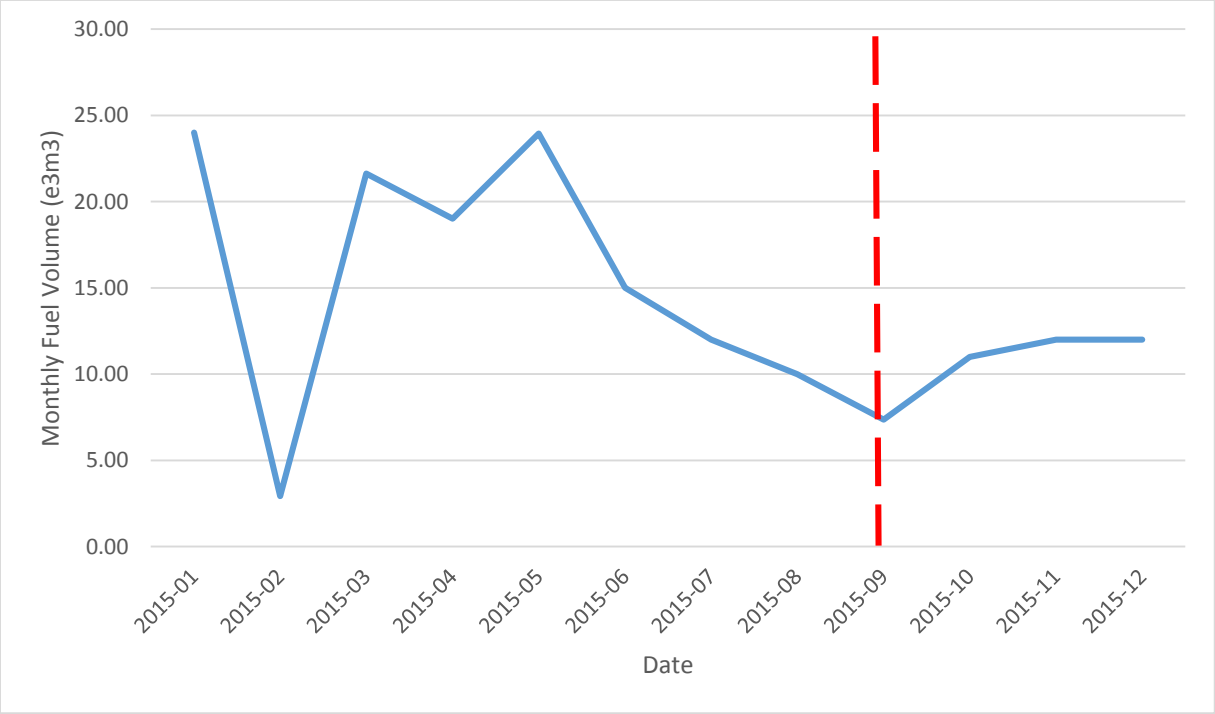
Figure 4 – 11-03-49-05W4 Monthly Fuel Use

Figure 5 – 11-03-49-05W4 Daily Gas Sales Volumes



Based on the graphs displayed in Figure 4 and Figure 5 it can be concluded that there is no increase in sales or fuel consumption following the June 2015, blower installation on the 11-03-49-05W4 site.

Figure 6 – 5-30-48-05W4 Monthly Fuel Use



It should be noted that since there was not a compressor previously on this site, propane usage on site was eliminated completely and the pad is now completely fueled by casing gas. Due to the erratic fuel volumes seen in Figure 6 it is difficult to conclude any optimized fuel usage by the 5-30-48-05W4 site. This is most likely due to a combination of poor propane usage data and varying gas volumes produced by the two wells on this site.

4.3 Production Volumes

Production data for the 100/11A-03-49-05W4, 102/5C2-30-48-05W4 and 103/5D-30-45-05W4 wells can be seen in Figure 7, Figure 8 and Figure 9. Both 5C2-30 and 5D-30 wells are connected to one blower compressor on the 5-30-48-05W4 site. Total fluid produced by each well is indicated by the green line in each graph. This is the only data from these graphs that is pertinent to this pilot. The thick red line indicates when the Go Technologies compressor was installed on each site.

Figure 7 – 100/11A-03-49-05W4 Production Data

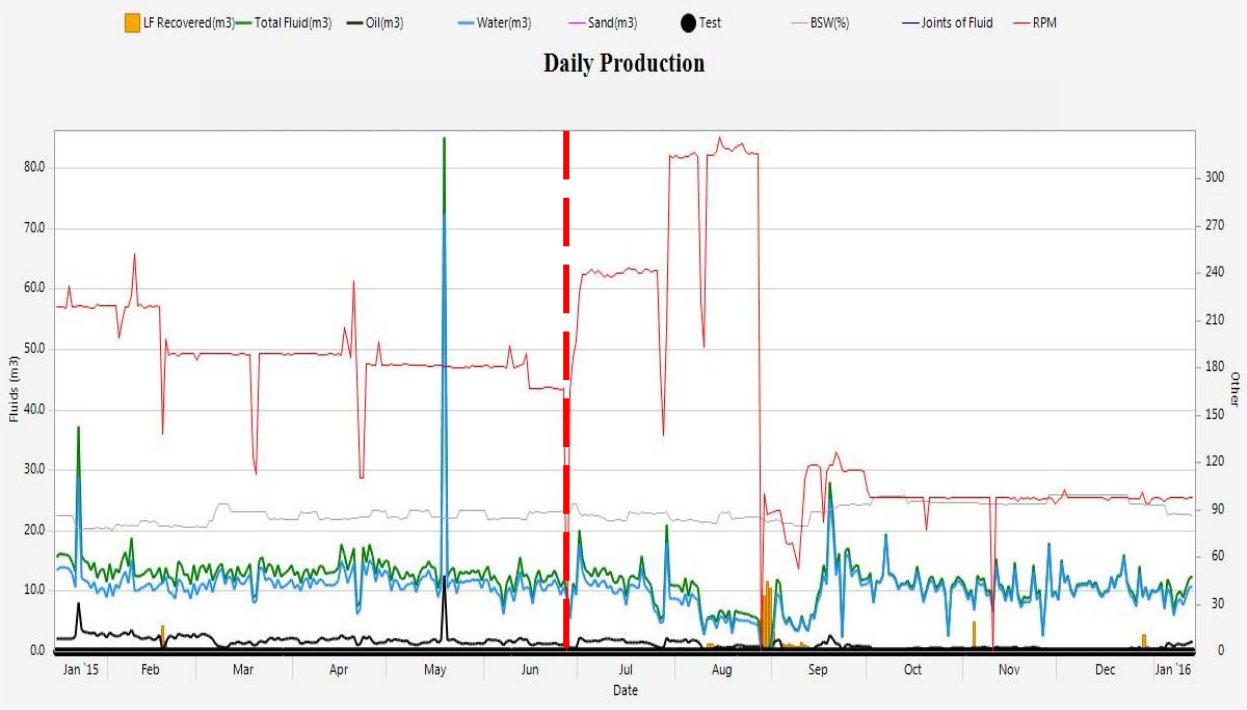
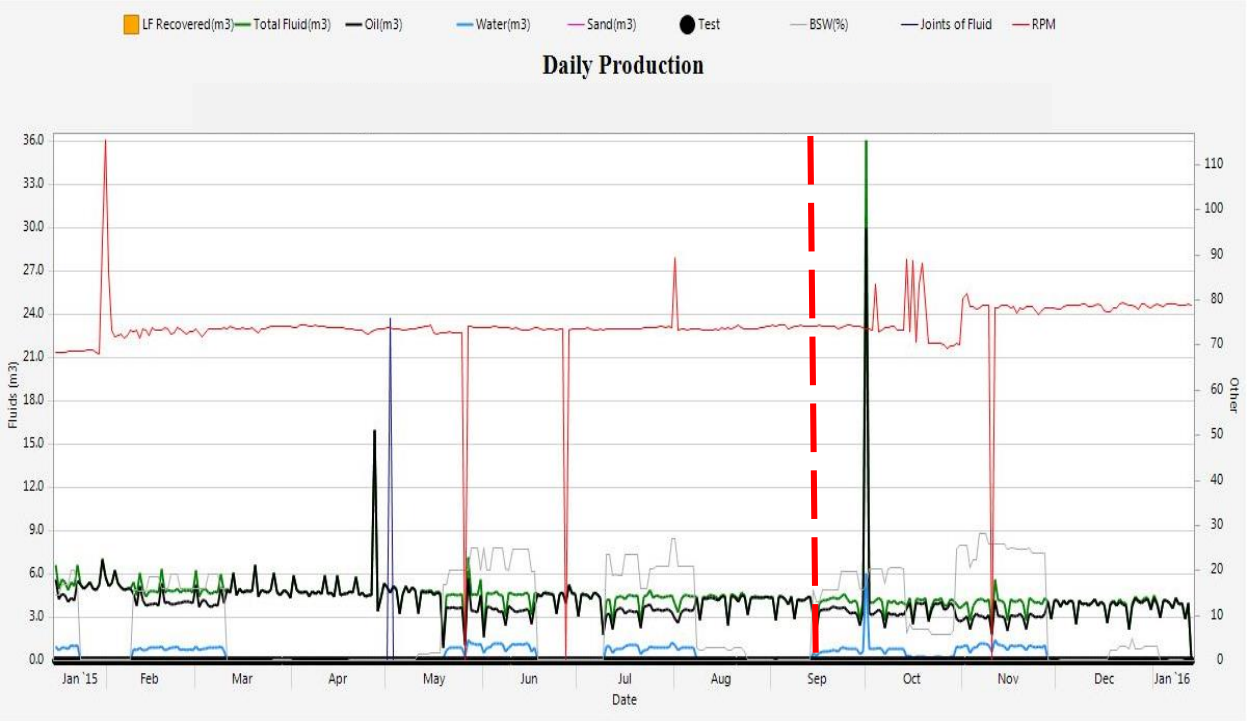


Figure 8 – 102/5C2-30-48-05W4 Production Data

Figure 9 – 103/5D-30-48-05W4 Production Data



The production trends for all three wells follow a standard decline curve (indicated by the relatively flat green fluid volume line) common in the Lloydminster district. There is no indication of production upsets or benefits as a result of the blower compressor installation.

4.4 Maintenance Conducted

Maintenance requirements of aging reciprocating compressors includes greasing, oil changes and belt replacement. The aging pieces of equipment experience significant downtime which increases casing gas system inefficiencies. This in turn causes more casing gas to be vented. The Go Technologies blower units required some initial suction and temperature set-point adjustments but have since required little attention from field maintenance staff. Operators and mechanics in the Lloydminster district are satisfied with the blower's servicing superiority to the reciprocating compressor units. It should be noted that the reciprocating compressor is commonly an aged piece of equipment in the CHOPS field. The age of this compressor significantly increases maintenance requirements.

5 Discussion

5.1 KPIs

Due to the sporadic nature of the vent volumes outlined in the results of this report an emissions reduction could not be identified. Increased casing gas collection efficiency also could not be identified since no increase was observed in the fuel and sales volumes on each pilot site. The flat production trends from each well did not indicate a reduction in casing gas pressure. The only benefit of the blower unit identified through the indicators is a reduction in site maintenance. The units were found to be easier to maintain when compared to their reciprocating counterparts.

5.2 Casing Gas Measurement Discussion

With recent regulatory changes and pressure from the AER, the measurement of casing gas vent volumes is only recently being advanced. Optimization of Gas to Oil Ratio (GOR) measurements and improved production reporting are being implemented to allow easier tracking of these vent volumes. Once these changes have been implemented and the field has greater confidence in volumes on a daily basis, it will become much easier to pilot new emission reduction technologies.

6 Conclusion

The Go Technologies Blower testing plan was developed and then executed resulting in stable operation of the compressors on two well pad sites. The reduced maintenance objective of the pilot was met however measurement of reduced vent volumes, efficient fuel use and increased oil production was inconclusive due to gas production characteristics and limited measurement capabilities in the Lloydminster district.

There is potential that the blower will create casing gas efficiencies on locations beyond those piloted. With the Go Technologies compressors now in the control of field staff, the Bonnyville/Lloydminster district has the option to try the blower compressors out on additional sites at minimal cost.

Based on the findings of the pilot Devon Canada plans to proceed with the following:

- Monitor the blower compressors currently in place and seek out alternative sites that would see a greater benefit from these units.
- Continue to evaluate casing gas systems in the field and optimize sites through the use of existing compressors.
- Compressor evaluation has been seriously limited by gas measurement techniques currently employed in Bonnyville and Lloydminster. Casing gas venting reduction technologies would benefit greatly from advancement in gas measurement technology in the CHOPS field.

- Investigate alternative casing gas technologies to mitigate venting issues currently seen in the Bonnyville/Lloydminster field.

Appendix A – Go Technologies Blower Specifications

Sutorbilt Legend Model 5H - Mechanical Seals

Price:

Click to enter price

Project Specifications

Corrected Values	Original Units	English Units	Metric Units
Barometer	3000 ALTI-FT	13.151 PSIA	0.907 bar a
Elevation	3000 ALTI-FT	3000 ALTI-FT	914 alti-m
Inlet Pressure	0 PSIG	0 PSIG	0 bar g
Inlet Temp.	68 °F	68 °F	20 °C
Inlet Flow	235 ICFM	235 ICFM	399 m³/h
Dis. Pressure	12 PSIG	12 PSIG	0.827 bar g
Rel. Humidity	36 %	36 %	36 %
Delta Pressure	12.5 PSI	12.5 PSI	0.862 bar

Measured Values	Plot Units	English Units	Metric Units
Blower Speed	2439 RPM	2439 RPM	2439 RPM
% of Max Speed	86 %	86 %	86 %
Blower Power**	20.2 HP	20.2 HP	15.1 kw
Efficiency	48 %	48 %	48 %
Discharge Temp.	245 °F	245 °F	118 °C
Estimated Noise	91 db	91 db	91 db

**Drive losses not included

Physical:

Weight	196 lbs.
Gear Diameter	5 in.
Case Length	4 in.
Port Size	2.5 in.
WR²	1.24 lb-ft²
Configuration	Vertical

Performance:

Max Delta P	15 PSI
Max Temp	300 °F
Max speed	2850 rpm
Min speed	1070 rpm
Max Case Pressure	25 PSIG
Max Delta T	200 °F
Max T	300 °F

Gas Parameters	English Units	Metric Units
Molecular Weight	16.06 lbm/lbmol	16.06 kg/kgmol
R Value	95.83 ft.lbf/lbm.R	0.52 kJ/kg.K
Density	0.036 lbm/ft³	0.583 kg/m³
Sp. Heat @ Const. P	0.52 BTU/lbm.R	2.16 kJ/kg.K
Ratio of Sp. Heats	1.31	1.31
Saturated Vapor Pres.	0.3388 PSIA	0.023 bar a
Partial Pres. of Gas	13.0293 PSIA	0.898 bar a
Partial Pres. of Vapor	0.122 PSIA	0.0083 bar a
Reference Pressure	14.696 PSIA	0.907 bar a
Reference Temperature	68 °F	0 °C
Reference Rel. Humid.	36 %	0 %

Gas mix: % by volume

Methane 100 %

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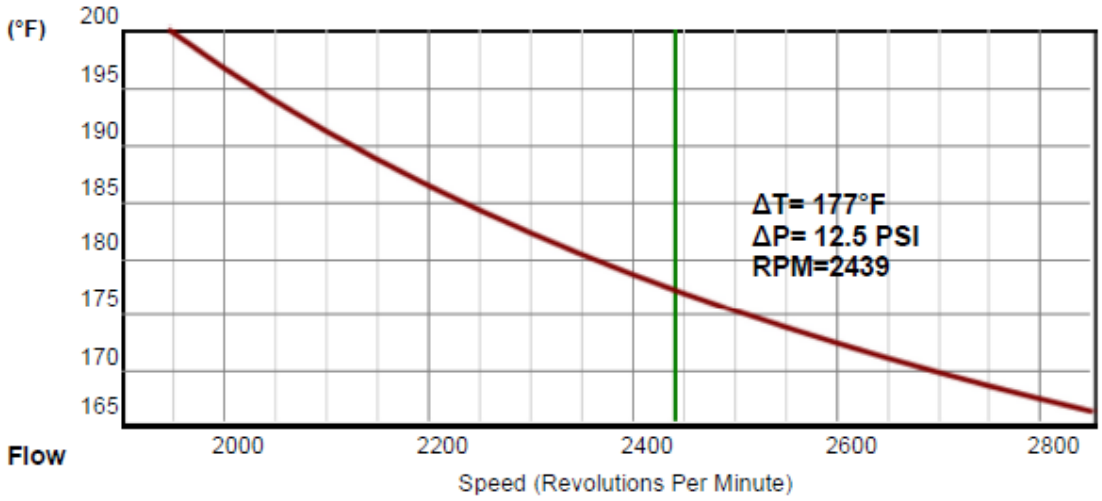
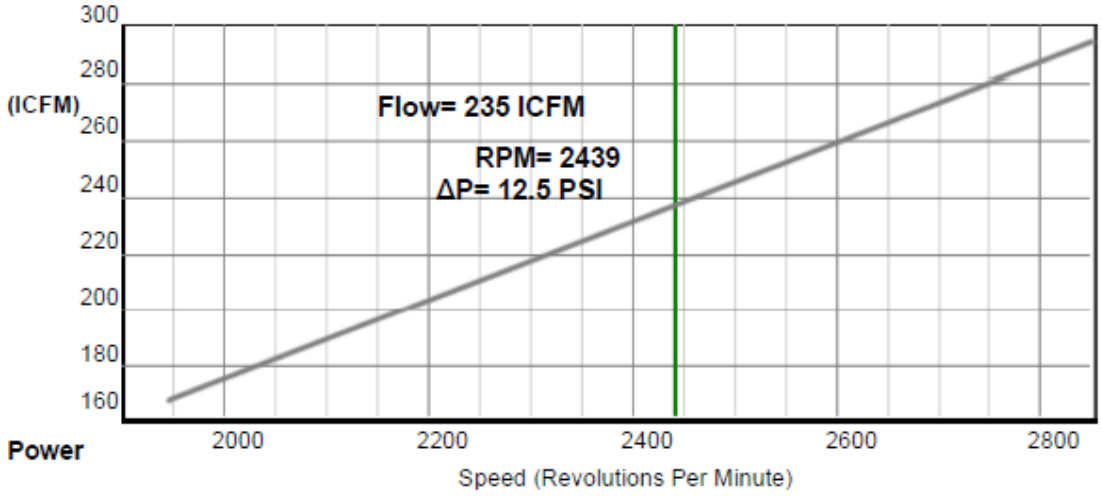
Performance Information - Sutorbilt Legend Model 5H

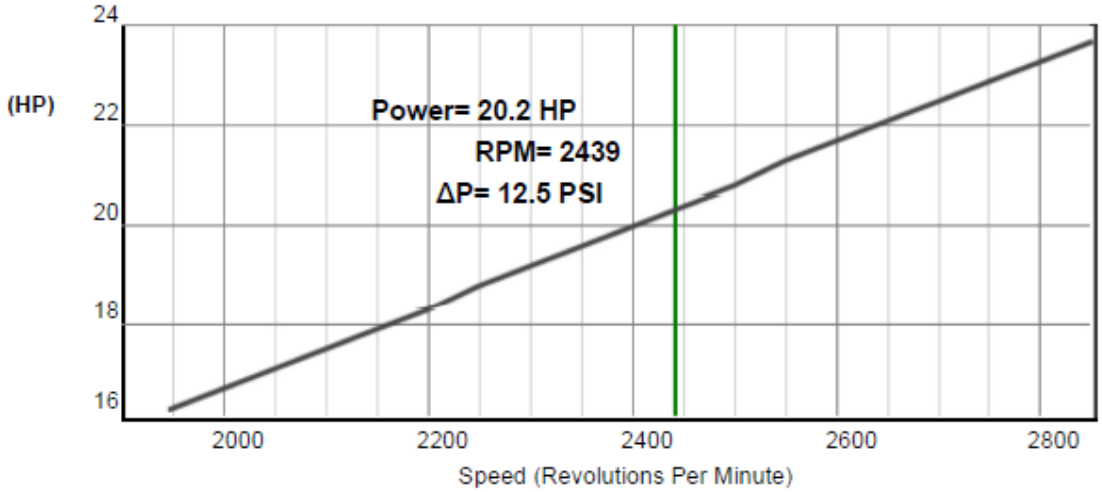
Temperature Rise



Flow



Power



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