# COMPLETE ROD CONTROL
# REVIEWING EXTREME CASES AND
# EXPLORING CRC FIBERGLASS SUCKER RODS

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Black Mamba Rod Lift

## HISTORY

At Southwest Petroleum Short Course 2022, a colleague, Jonathan Martin, presented a paper titled *Complete Rod Control Provides Unmatched Reliability in Rod Lift Systems.* At that time, thorough data from Complete Rod Control™ and the aggressive wells presented did not have substantial run time behind them. Shortly after SWPSC 2022, Complete Rod Control™ became available in aliphatic polyketone material. This has resolved some pitfalls of the original material offered by Black Mamba Rod Lift for achieving Complete Rod Control™.

Now in April 2023, a more thorough review is available.

For an understanding of the mechanics of Complete Rod Control, please review the April 2022 paper from Martin.

## A NEW APPROACH TO ROD LIFT

Controlling sucker rod instability in the system and string provides much more reliability for beam lift wells – the elimination of significant bending moments due to sucker rod buckling prevents pre-mature sucker rod failure.

Common practice in rod lift is to keep polished rod velocities below 1,440 IPM. This is primarily due to keeping the rod string and system under control.

$$Polished\ Rod\ Velocity, inches\ per\ minute = (Strokes\ per\ Minute)(Stroke\ Length)$$

As quick reversals occur, physics and the wave equation come into play, and compression is more likely to occur. With a standard rod string not mechanically stabilized, this compression is problematic and leads to absolute pre-mature rod failure.

Common practice has been to slow down the rod string and use larger pumps to increase fluid production. Larger pumps in fluid pound conditions encourage and cause more aggressive negative loading from the pump upward. Further, larger pumps increase axial loading of the sucker rods, and larger rods are required for strength. These two factors combined increase side-load, which then increases the risk of rod-on-tubing wear and pre-mature system failure.

By utilizing a smaller pump, increasing the speed of the pumping unit, and pumping faster albeit with an IN-CONTROL rod string, the operator can meet larger production targets with ease and reliability.

## CASE INTRODUCTION

This paper was written with the consent of Chevron, though co-authoring approval was not available with the time limitations of the Short Course deadlines. Black Mamba has been granted approval for referencing Chevron's pilot program of Complete Rod Control™ on steel rod strings, and Chevron is actively deploying fiberglass configurations with End-to-End Rod Control (10 Black Mamba XL guides per rod). Chevron's piloting of Complete Rod Control™ came after Ryan Blake of Chevron sat in on Martin's 2022 presentation. Cases 1 – 3 are various problem wells of Chevron. All rods utilized feature 7 per Complete Rod Control™ configuration.

Case 4 is a review of a single well on a multi-well pad operated by Longfellow Energy and is an extreme application for rod lift. All steel rods utilized feature 7 per Complete Rod Control™ configuration.

Case 5 is a brief review of prior Diamondback wells (presented in Martin's 2022 paper) which are still doing well today. All steel rods utilized feature 7 per Complete Rod Control™ configuration.

Case 6 is a look into the first fiberglass well guided with Complete Rod Control™.

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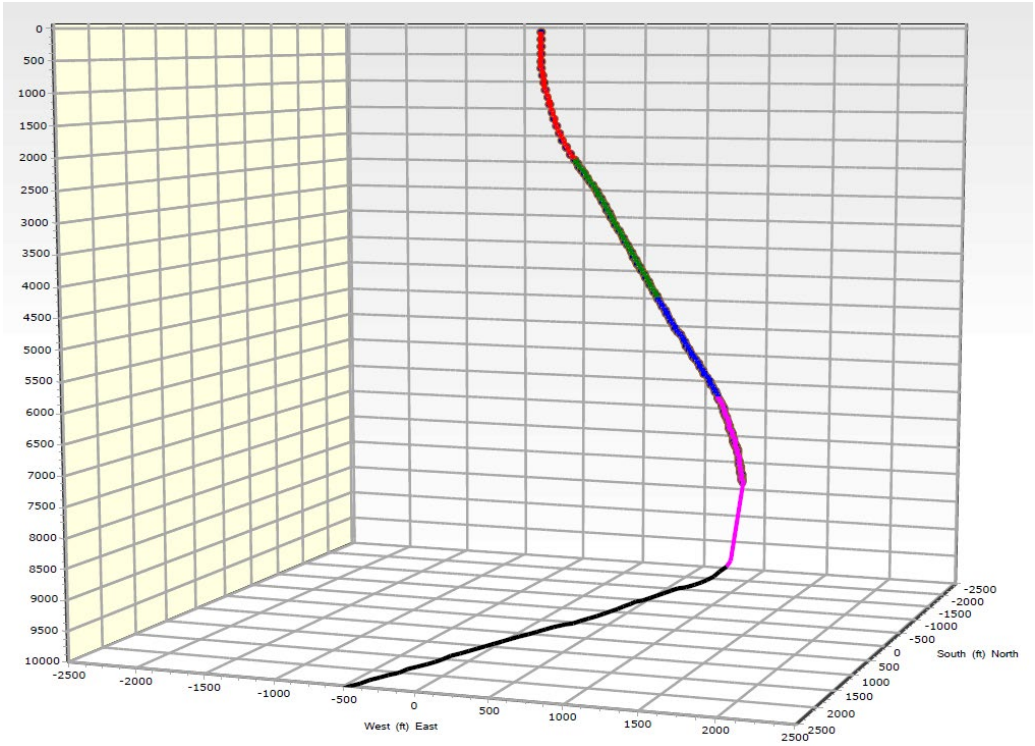
### Case 1 – Chevron A

Complete Rod Control™ is a desired test due to a variety of conditions. Complicated drill, high-kick DLS, which results in extreme side-load(s). This well features constant inclination and is guided for Complete Rod Control™ from top to bottom.

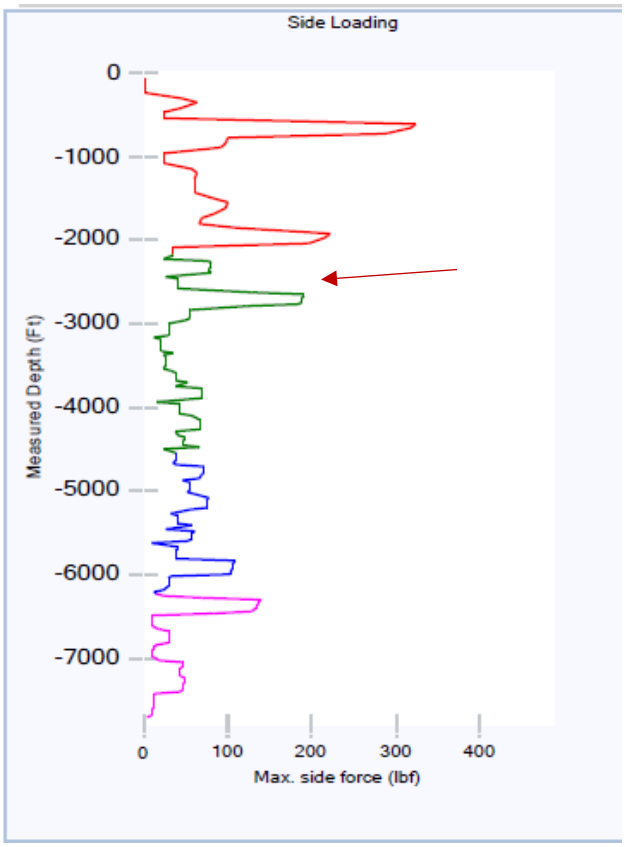
Installation Date: August 2022

Pumping Unit: 912-427-192, Hole 2
Stroke Length: ~164"
Pump Size: 1.75" Insert
Designed SPM: 7 SPM
Polished Rod Velocity: 1,144 IPM

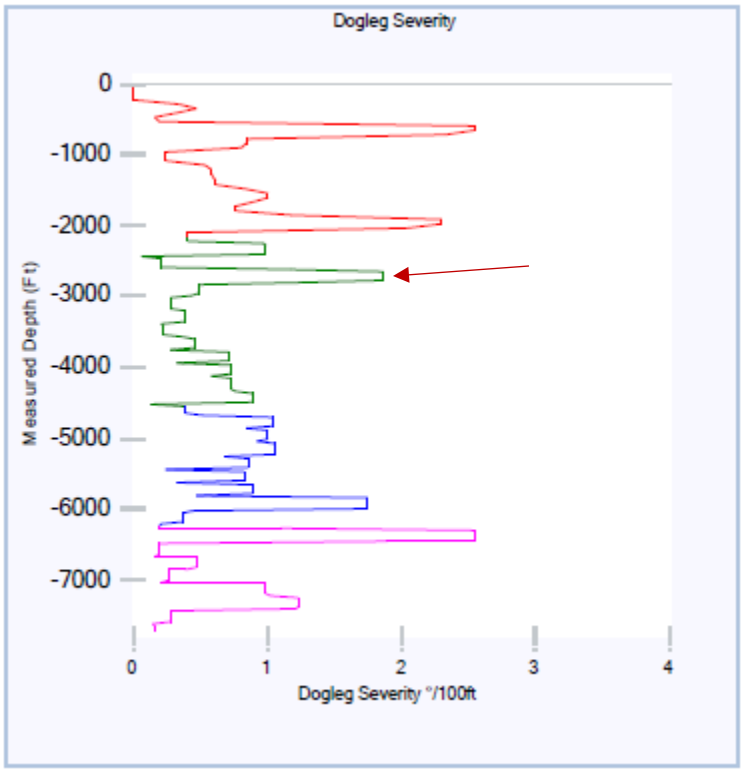
General assessment – safe, basic approach for Complete Rod Control™




3D Survey.




Side-Load (truncated from low-res survey).



DLS (truncated from low-res survey).

Status: Exceeding expectations. Sister wells have pumped with other guided rod string designs or continuous sucker rod designs, however, stick rod and bending-moment mitigation through CRC has created a positive experience with extended times.

This is one of 28 wells in the Chevron Complete Rod Control™ library.

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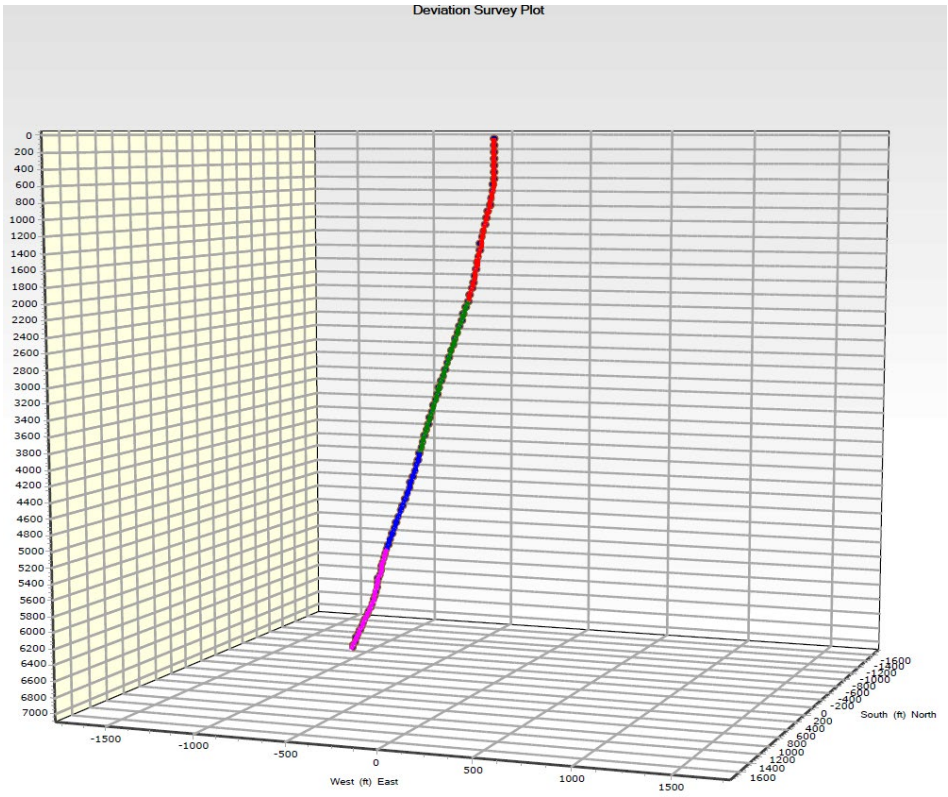
Case 2 – Chevron B

Chevron C features constant inclination and a curve from surface, like Martin's 2022 paper which touches on 'banana drills' right from surface.

Installation Date: October 2022

Pumping Unit: 912-427-192, Hole 2
Stroke Length: ~164"
Pump Size: 1.75" Insert
Designed SPM: 7.5 SPM
Polished Rod Velocity: 1,230 IPM

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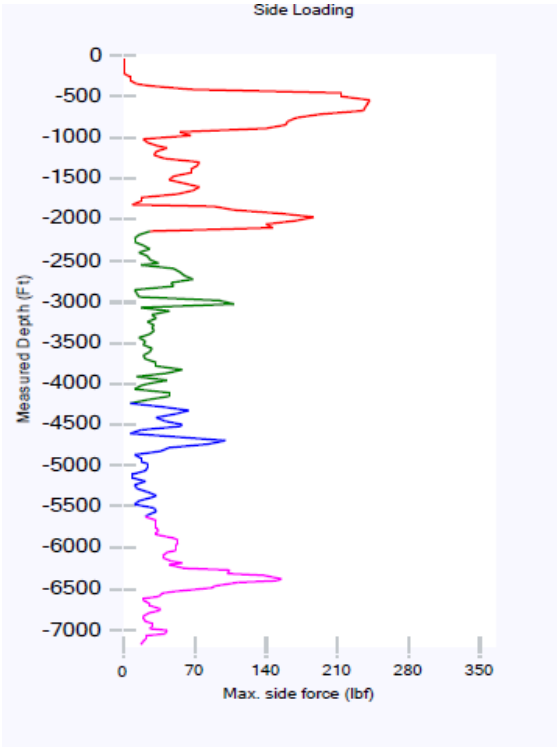


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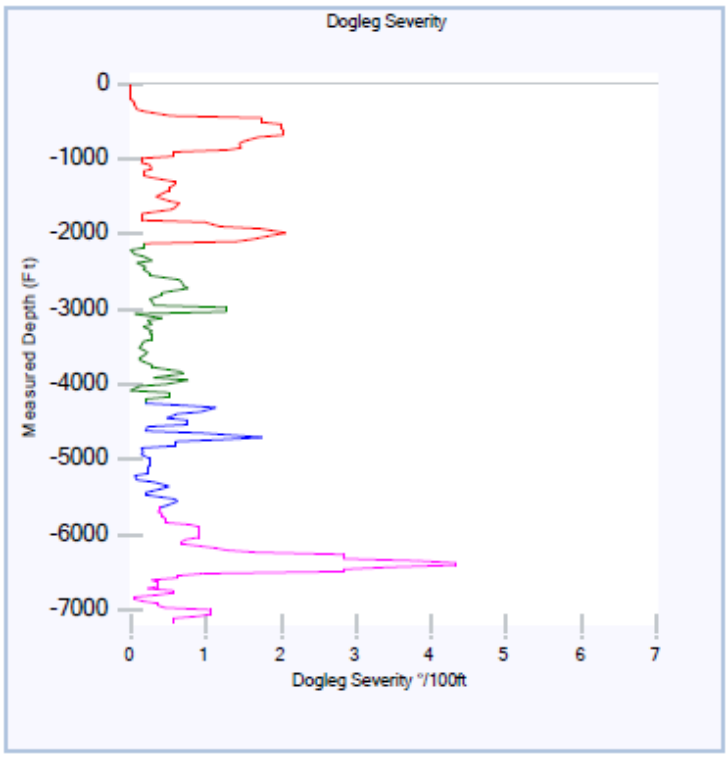


DLS.

Status: Pumping well, all smiles.

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Case 3 – Chevron C

This well has been a talking point and a thorn in the side of Chevron for some time. Complete Rod Control™ is utilized top to bottom on DS+ rods (125 ksi rods such as Weatherford KDP or Norris N75).

Installation Date: July 2022

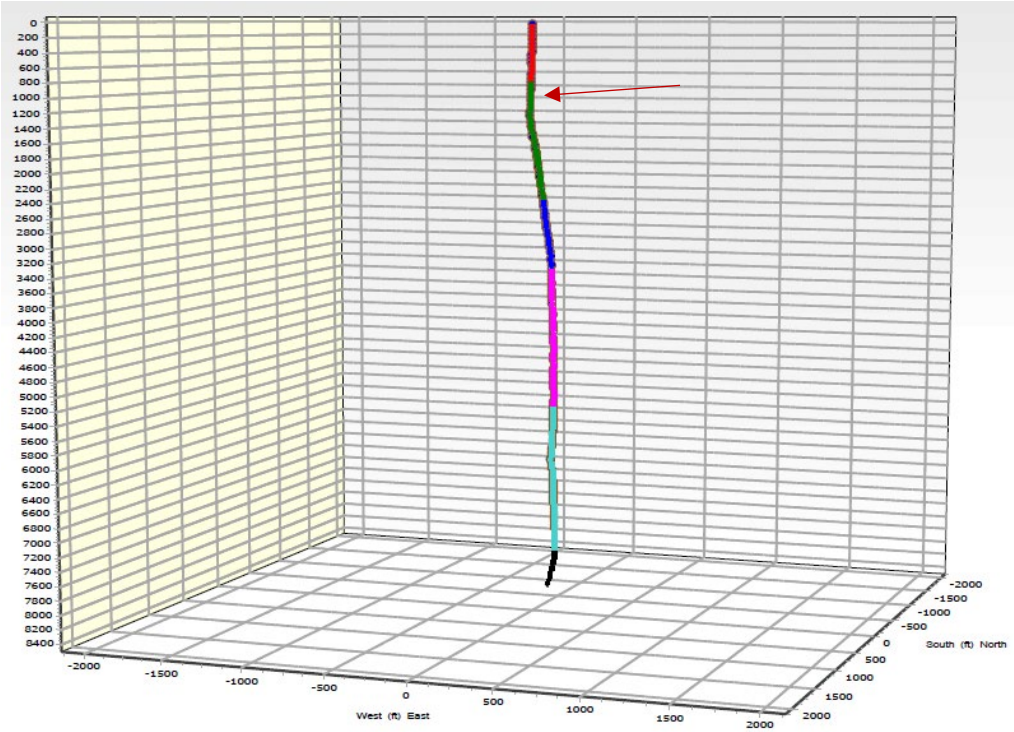
Pumping Unit: 912-365-192, Hole 1
Stroke Length: ~193”
Pump Size: 1.5” Insert
Designed SPM: 7.7 SPM
Polished Rod Velocity: 1,486 IPM

General assessment:

This well features slightly quick pumping speeds for standard rod lift practices. With Complete Rod Control™, this is not a concern for the operator. Drilling did a poor job near

1300’ MD. An immediate direction change created a 10-degree dogleg and an associated 900 lbf side-load.

Many rod-lift approaches would result in an unacceptable run time.

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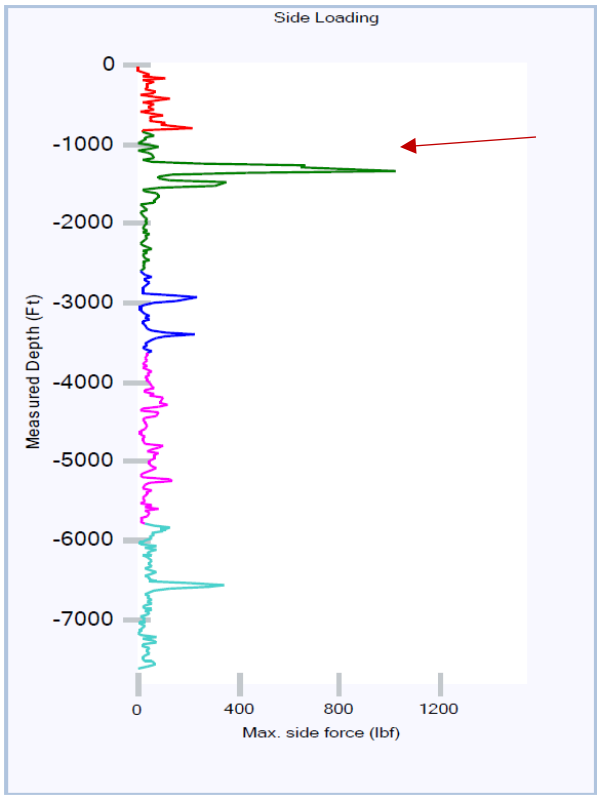


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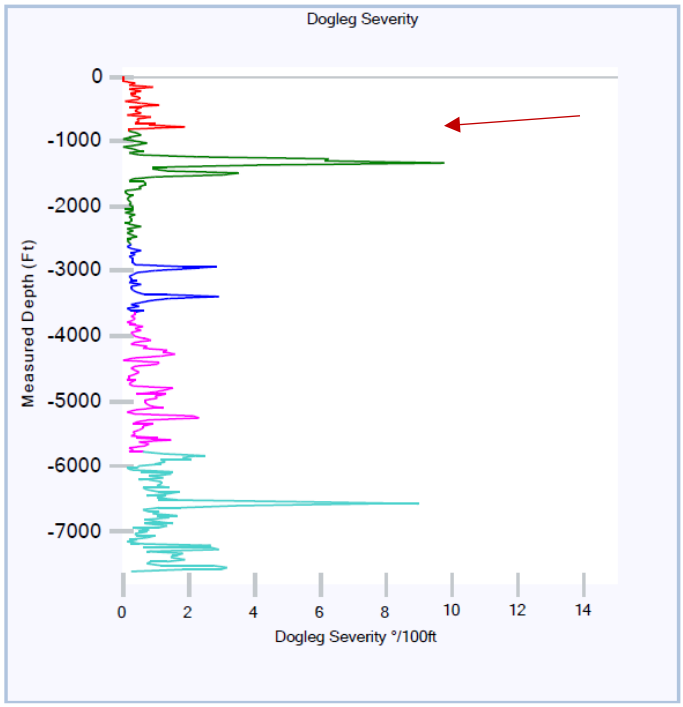


DLS.

Status: Exceeding expectations. Complete Rod Control™ reliability is astonishing for such an extreme high kick.

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Case 4 – Longfellow – Extreme production in an extremely abusive environment

This well represents several drills on a multi-well pad. For 6 months straight, the operator threw everything at the well, fully blinged out with rods, guides, tubing poly-liner, fancy pumps, fancy gas separators, and includes a Rotaflex pumping unit. Their best run time – 9 days. Average pad run time: 15 days.

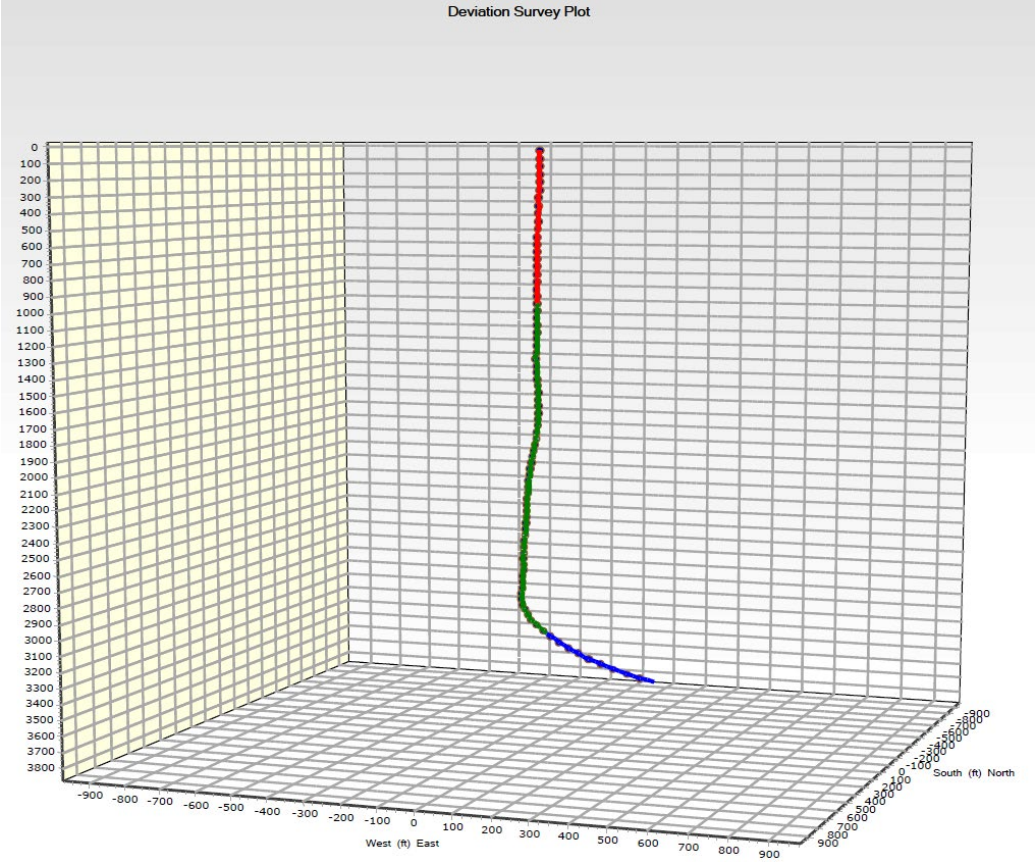
Installation Date: April 2022, Design Revised August 2022

Pumping Unit: Rotaflex R-350-500-366
Stroke Length: ~366”
Pump Size: 3.25”
Designed SPM: 3.2 SPM
Polished Rod Velocity: 1,171 IPM

General assessment:

This well is lifting over 1,000 bfpd. The 3.25” tubing pump should be down-sized to reduce side-load fears and abuse. The reservoir is plagued with sand from formation and from frac. Side-load varies throughout the entire well from 300 – 500 lbf, peaking in the curve at close to 1,200 lbf per rod.

Some rod lift designers have called this unpumpable.

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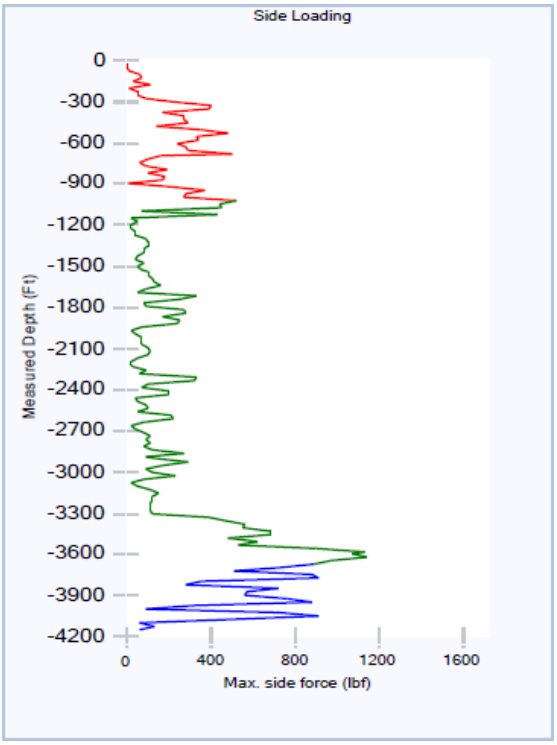


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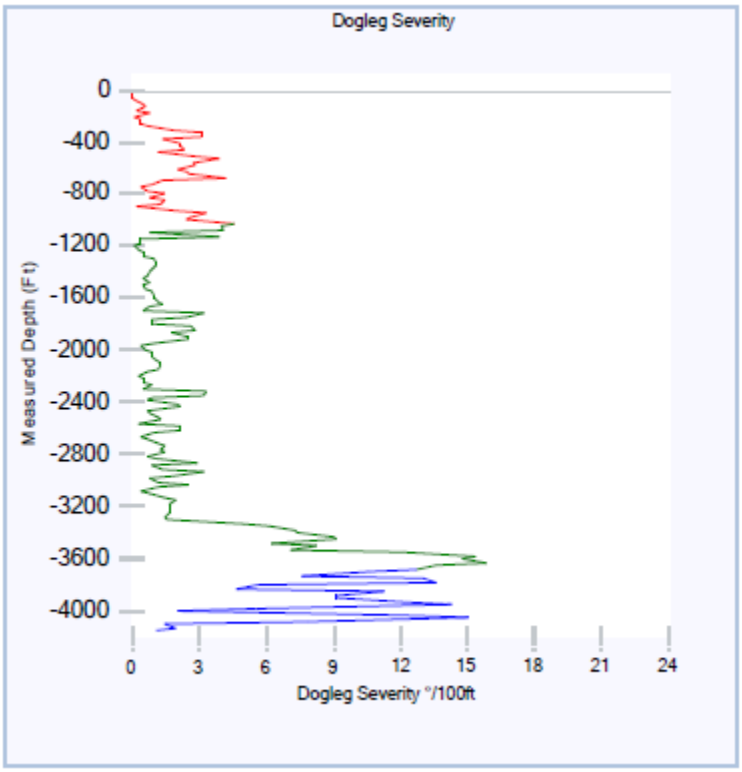


DLS.

Status: First run time under Complete Rod Control™ conditions eclipsed the prior best by 10x. The pump was pulled for service, there was no rod failure. At that time, the operator opted to upgrade to the new aliphatic polyketone variant of Complete Rod Control™.

Since August 2022, this well continues to produce reliably, approximately 21x the operators best run time with other options and solutions. The path forward for the operator is conventional pumping units and insert pumps which will lead to even more reliability, and quicker service since tubing does not need to be pulled.

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Case 5 – Diamondback – A view of high-velocity high-volume pumping

As an experiment for high-speed, high-volume pumping, this well is still pumping today under conditions slightly less than as designed (8.4 SPM).

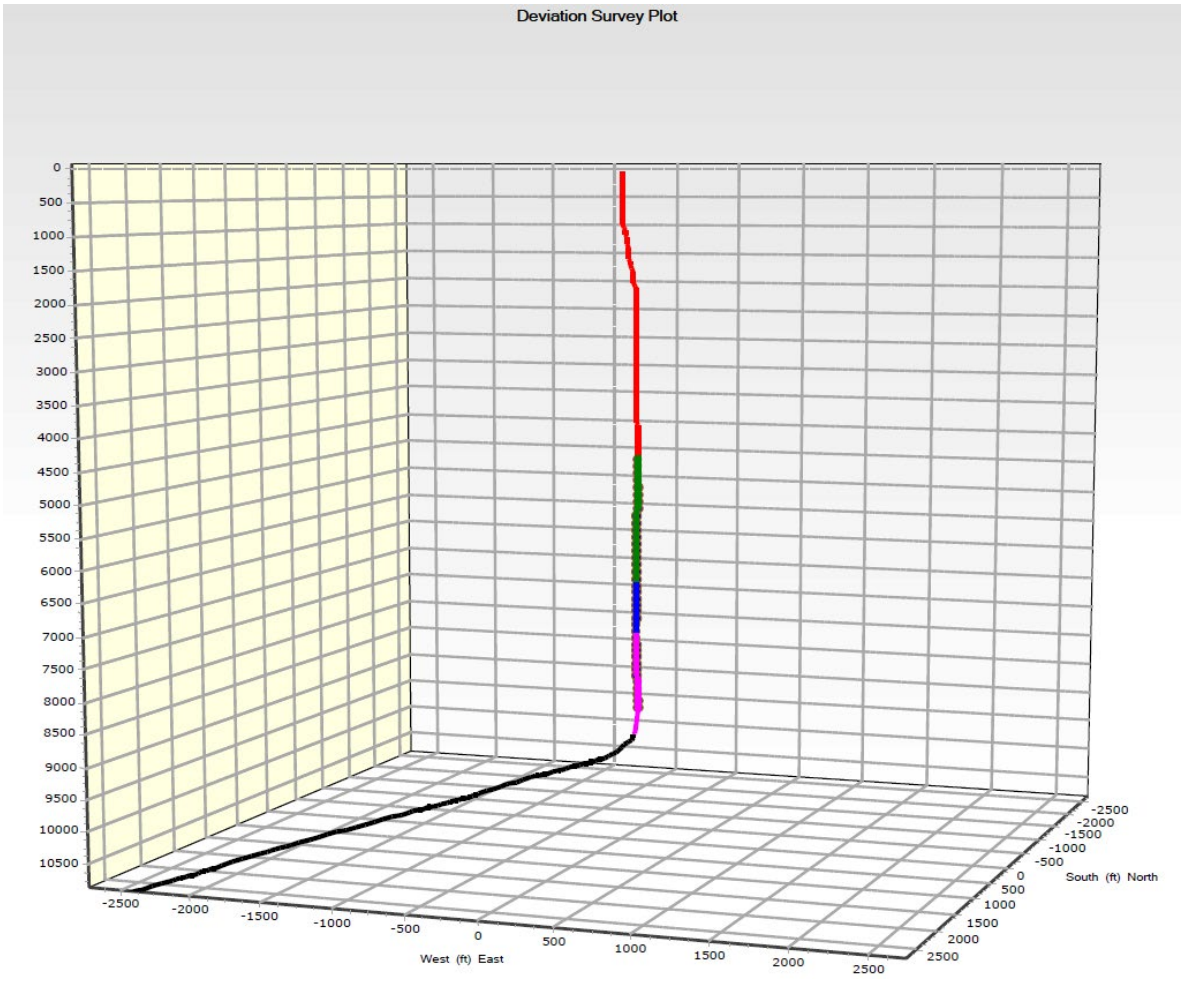
Installation Date: February 2022

Pumping Unit: 1280-365-240, Hole 2
Stroke Length: ~205”
Pump Size: 2” Insert
Designed SPM: 9 SPM

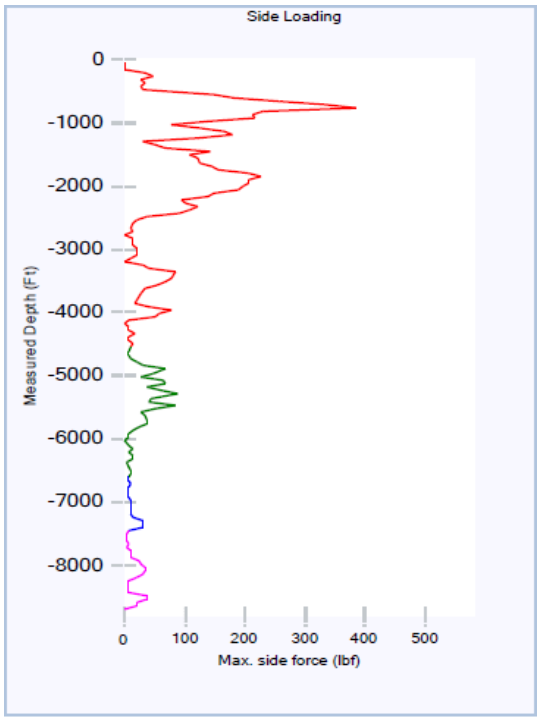
Polished Rod Velocity: 1,845 IPM

General assessment:

This well features pumping speeds inside the threshold for pumping unit capability, but approximately +30% faster than standard rod lift practices. A 2-degree dogleg near surface looks worse in the 3D visual than it is.




3D Survey.

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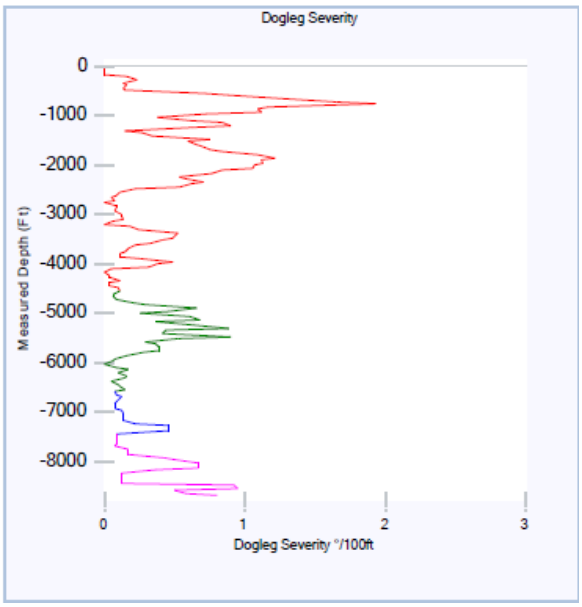


DLS.

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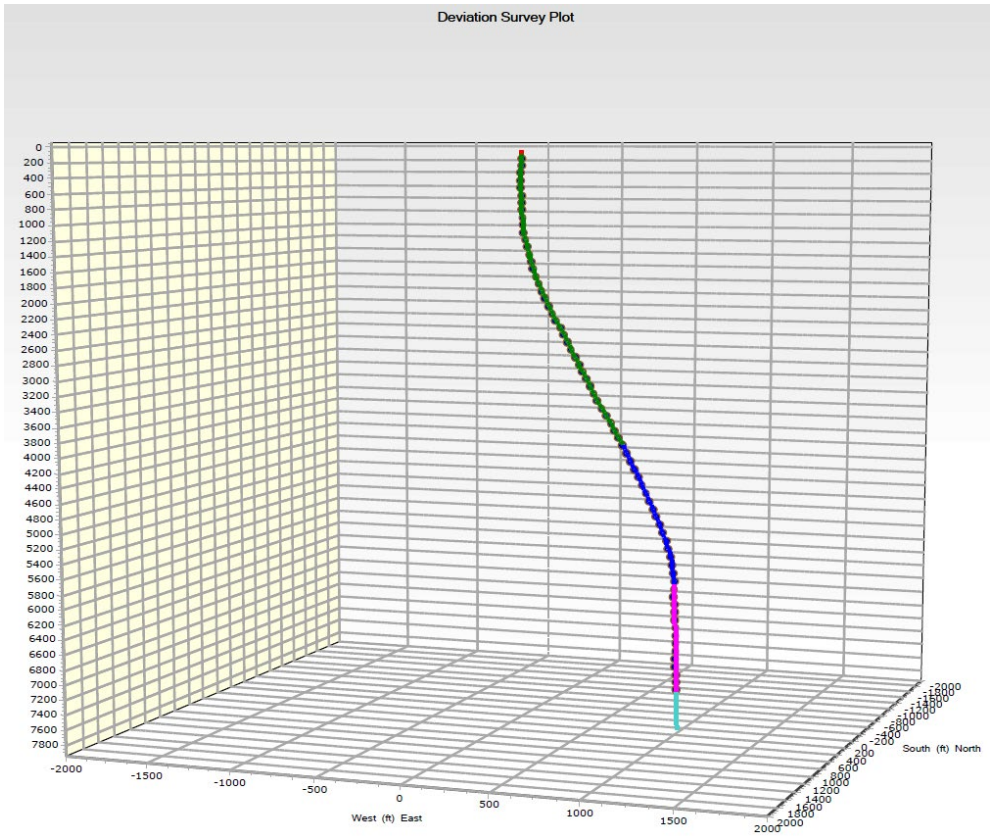
Case 6 – Chevron D

Fiberglass is new for Complete Rod Control™. Due to the successes of the steel trial program, Chevron has installed a fiberglass rod string guided for Complete Rod Control™. Its run time and success are to be determined. The drill design is similar to that of other installs featuring Complete Rod Control™. There is significant back-and-forth DLS throughout the fiberglass section, which makes this an aggressive, well-rounded test.

Installation Date: March 2022

Pumping Unit: 640-365-168, Hole 2
Stroke Length: ~144”
Pump Size: 1.75” Insert
Designed SPM: 7 SPM
Polished Rod Velocity: 1,008 IPM

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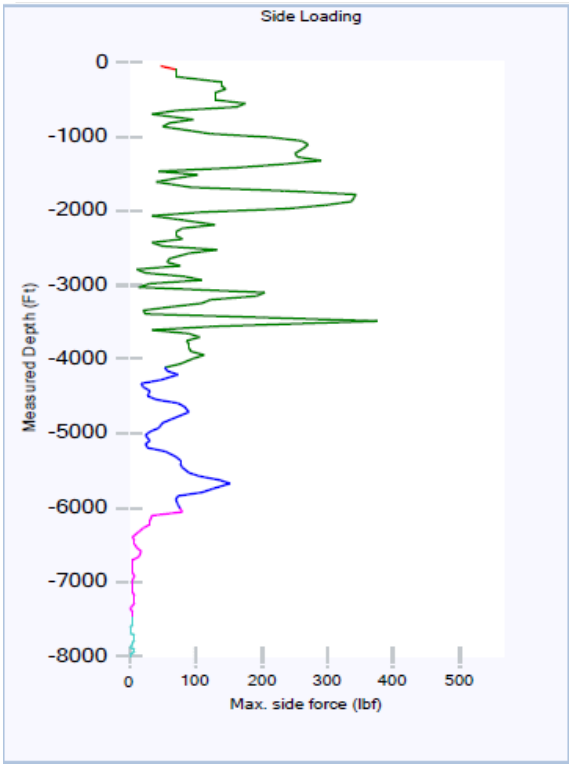


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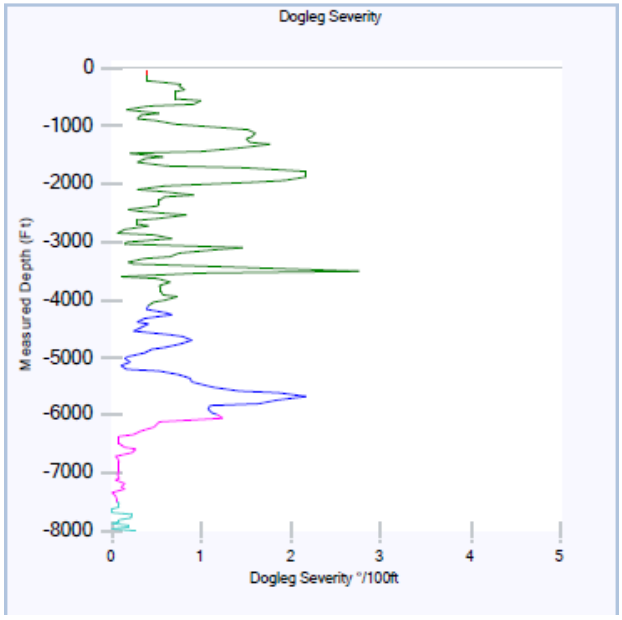


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SUMMARY

Complete Rod Control™ and Black Mamba® allows for a new wave in rod pumping, changing standard practices and what is considered safe. We as engineers must continue to ask “Why?” when perceived prior long-time historical limitations continue to be relied upon. The industry is evolving with new technologies daily; Complete Rod Control™ is a powerful tool which ***forces*** reliability and predictability into the rod string.

Sucker rods no longer operate as long slender columns which are highly sensitive to negative loading and compression.

- Pumping units can operate faster - 1,000 bfpd wells on rod pump is no longer challenging.
- String design can become a more simple, cookie cutter operation.
- Side-load computation becomes secondary as Complete Rod Control™ fully centralizes and protects sucker rod strings.

This patented, economical solution provides perfect sucker rod reliability in a well-engineered and validated design and system. Multiple operators big and small have tested and validated the effectiveness of Complete Rod Control™ (CRC) since 2019.

The methodology of Compete Rod Control™ is simple – compression cannot be avoided. Address it head on.

REFERENCES

[1] J. Martin. *Complete Rod Control Provides Unmatched Reliability in Rod Lift Systems*. Southwestern Petroleum Short Course, 2022.