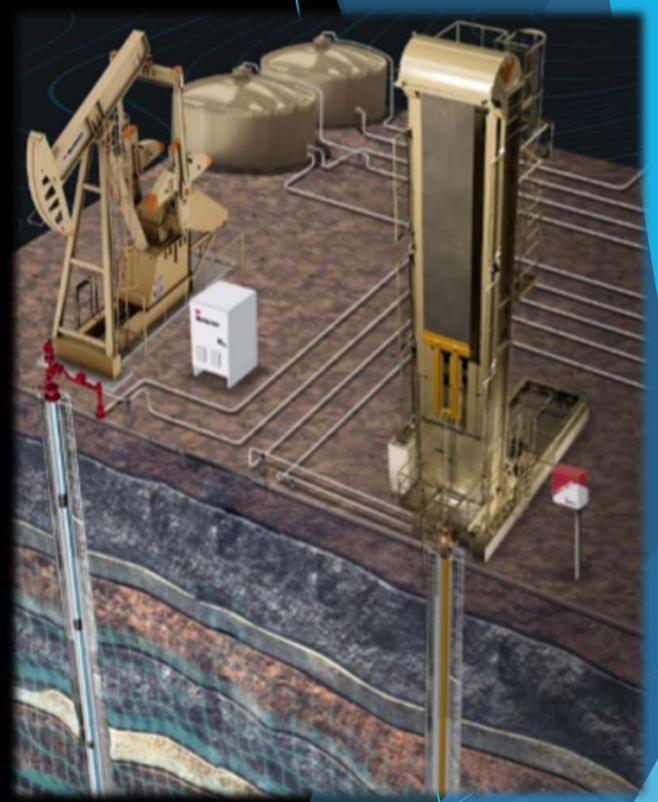
Artificial Lift R&D Council

2021 International Sucker Rod Pumping Virtual Workshop

February 8-12, 2021



Rod Pumping “Unpumpable” Wells

Western Falcon Energy Services and Weatherford

Weatherford®

Western Falcon Energy Services

ABSTRACT

Unconventional producers challenged by low oil prices, continuously seek new opportunities to reduce LOE and increase profits.

Many new wells are initially equipped with ESP's to achieve the high production volumes required. These ESP systems often experience short runtimes due to frac sand production and severe gas interference associated with producing new unconventional wells. The short runtimes combined with the high cost of ESP repairs force production engineers to closely monitor production volumes for the earliest opportunity to convert from ESP to SRPS.

Well depth, deviation / tortuosity and the high production volumes result in very high downhole friction in conventional SRPS contributing to pump, rods and tubing failures. For this reason, many wells are considered "unpumpable" with SRPS until production volumes fall below the 400-450 BPD range.

This presentation will demonstrate how combining new and existing SRPS technology can greatly expand the production range in these wells, up to 1000 BPD, while reducing equipment failures and increasing overall system efficiency.

The engineered design and application of these technologies will allow engineers to transition away from ESP to SRPS much sooner in the life of the well, resulting in considerable LOE savings and increased profits.

TECHNOLOGY MISSION

- In July of 2020 Weatherford and Western Falcon signed a Global Mutual Collaboration Agreement. The purpose of this agreement was to:
  - Leverage artificial lift experience in both companies for the benefit of the customer.
  - Provide pricing advantages for producers through commercial packages.
  - Expand the operating envelope for sucker rod pumping systems (SRPS).
  - Combine technology offerings for longer run life ALS.

ESP CHALLENGES

- ESP's required for depth (10,000'+-) and high initial fluid volumes.
- ESP's are high cost to buy / rent, control, maintain and to operate.
- Low runtimes / high failures in unconventional resulting in high intervention and repair costs.
- Operators want to convert from ESP to SRPS as soon as possible in the life of the well.

SRPS CHALLENGES

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- SRPS historically limited in production at 10,000’ to 400 - 450 BPD (average).
- Historically, high failure rates and low efficiency caused by downhole deviation / friction due to wellbore tortuosity, especially at the higher production volumes.
- Less expensive to buy, operate and repair.
- Easier to control and not as adversely effected by high gas production.

SRPS SOLUTIONS

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- An engineered SRPS combining new and existing artificial lift technologies allows for earlier conversions.
- Capable of more than double the production rate of previous conventional SRPS systems.
- The combined technologies greatly expand the operating envelope, efficiency and reliability of these new SRPS.
- Minimizing **downhole friction** and number of pump cycles is paramount to efficient SRPS operations and long runtimes.

DOWNHOLE FRICTION

Friction depends primarily on the smoothness / roughness of the contacting surfaces. The rougher the surface the larger the force required to initiate and continue movement.

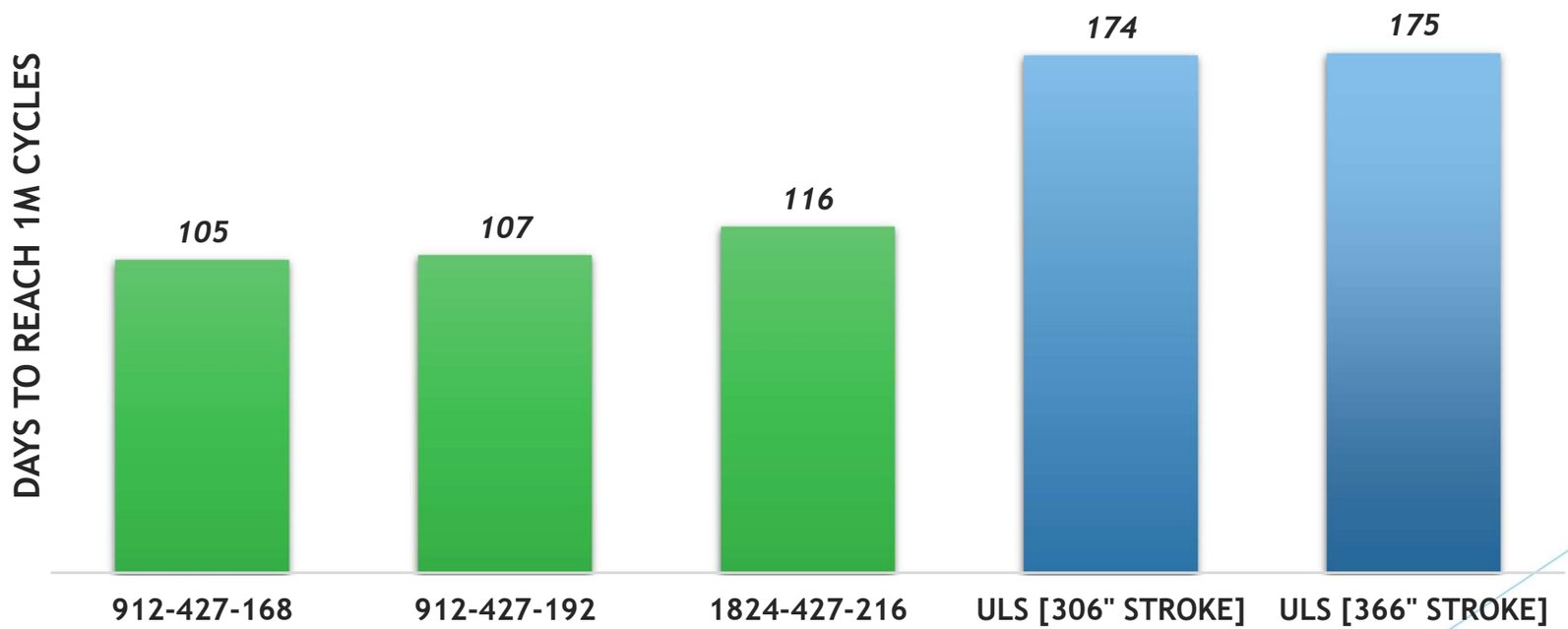
- Designing for downhole friction reduction must be a priority.
- Downhole friction consumes HP, reducing efficiency and increasing utility bills.
- Accelerates downhole equipment wear and corrosion.
- Increases failure rates and lifting costs.

FAILURES / ISSUES ATTRIBUTED TO FRICTION

- Wear and corrosion
- Holes in tubing (HIT)
- Sucker rod failures (body & connections)
- Operational downtime
- Lost / deferred production / revenue
- Increased HSE exposure

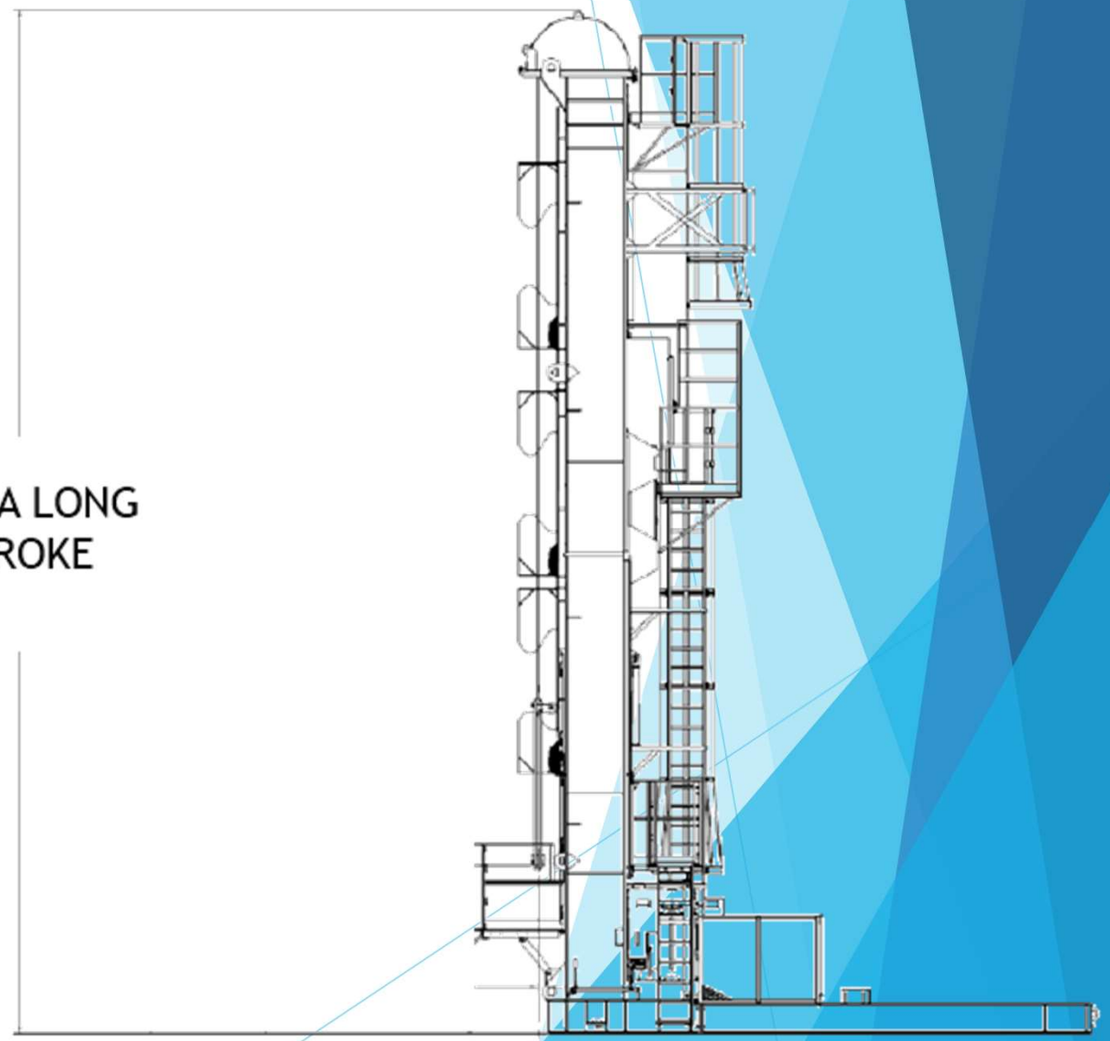
ULTRA LONG STROKE UNITS

- Ultra long stroke (ULS) units greatly reduce the number of pump cycles / barrel lifted.

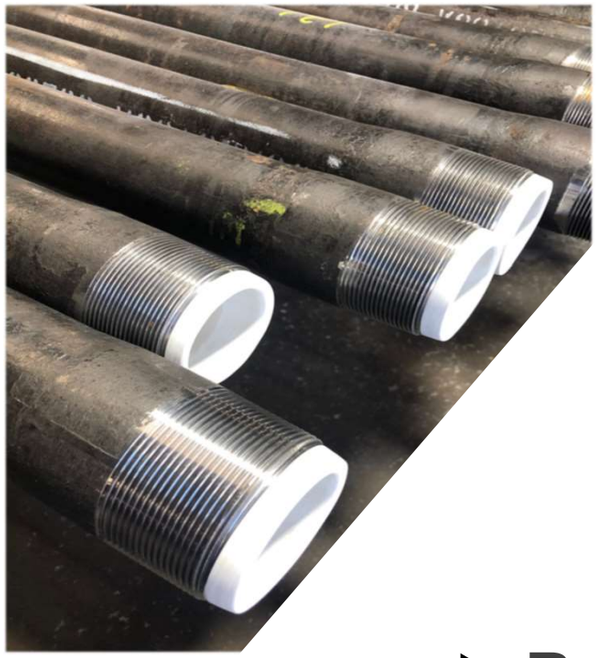


ULTRA LONG STROKE UNITS

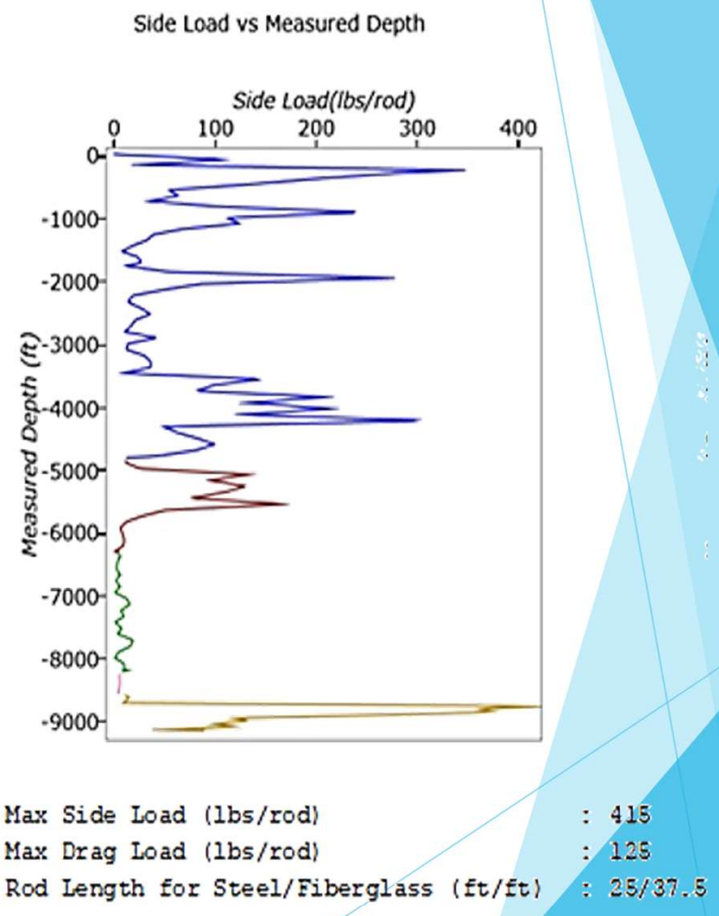
- Long, slow strokes reduce cycles.
- Improves HP transmission efficiency PRHP / PHP.
- Infinite SPM and cornering control can improve gas handling capability.



THERMOPLASTIC LINED TUBING



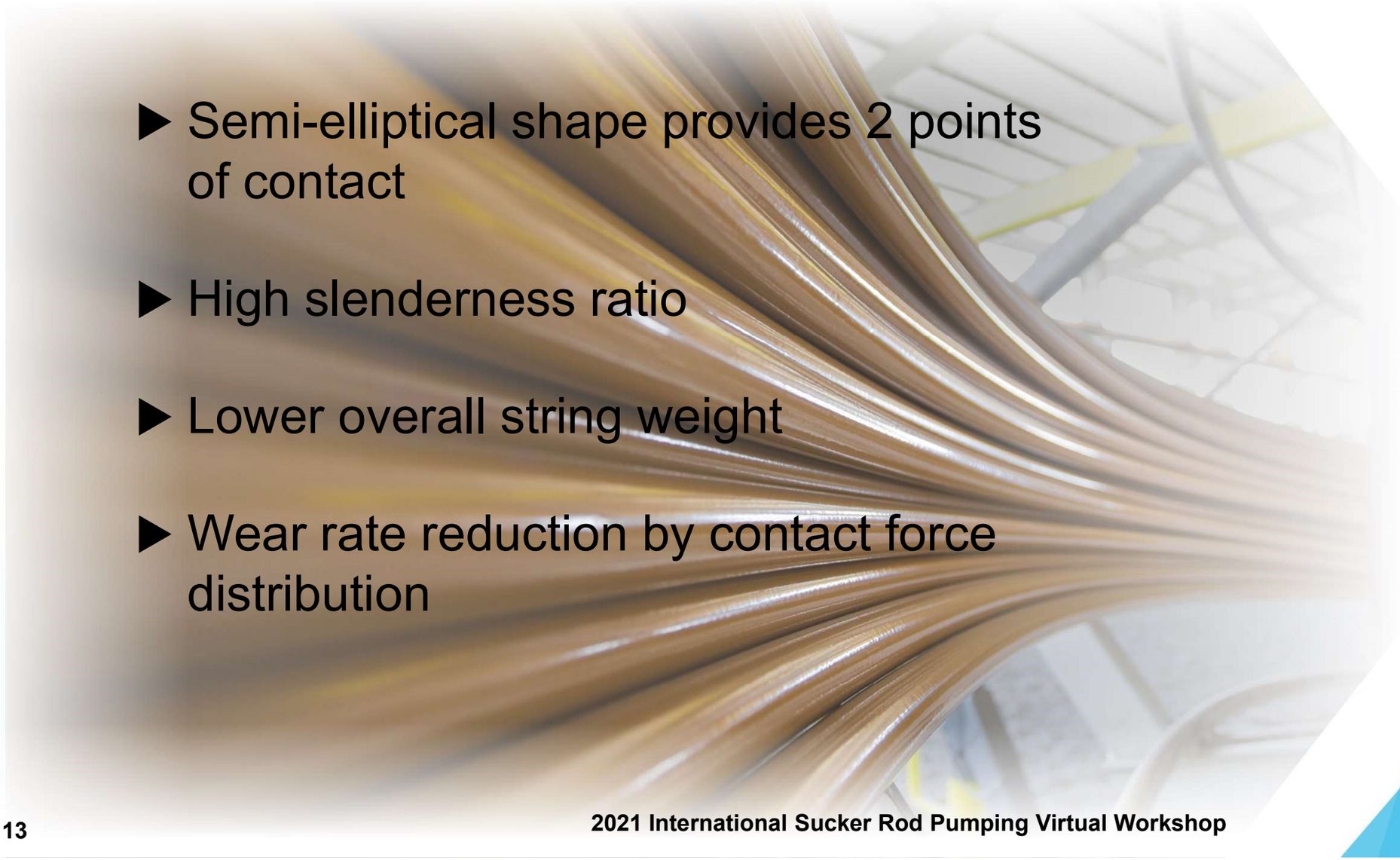
- Full string installations
  - Maximum friction reduction & corrosion / wear protection
- Partial installations
  - Targeted to specific high side-load wear areas



THERMOPLASTIC LINED TUBING

- Thermoplastic lined tubing (TPL) can reduce downhole mechanical friction by as much as 50% over bare tubing.
- TPL smooth ID and lubrication increases HP transmission efficiency PRHP / PHP.
- Provides an effective corrosion / wear barrier in the tubing ID.

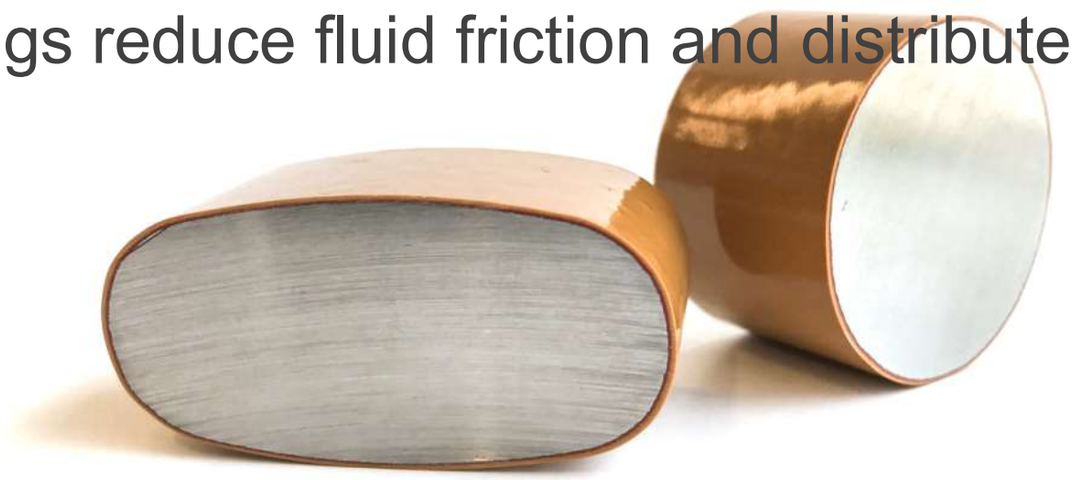
EPOXY COATED CONTINUOUS ROD



- Semi-elliptical shape provides 2 points of contact
- High slenderness ratio
- Lower overall string weight
- Wear rate reduction by contact force distribution

EPOXY COATED CONTINUOUS ROD

- Continuous epoxy coated sucker rod (CCR) further reduces downhole mechanical friction, increasing HP transmission efficiency.
- Coating protects the rod string from corrosion / wear.
- No couplings reduce fluid friction and distribute side loads.



EPOXY COATED CONTINUOUS ROD

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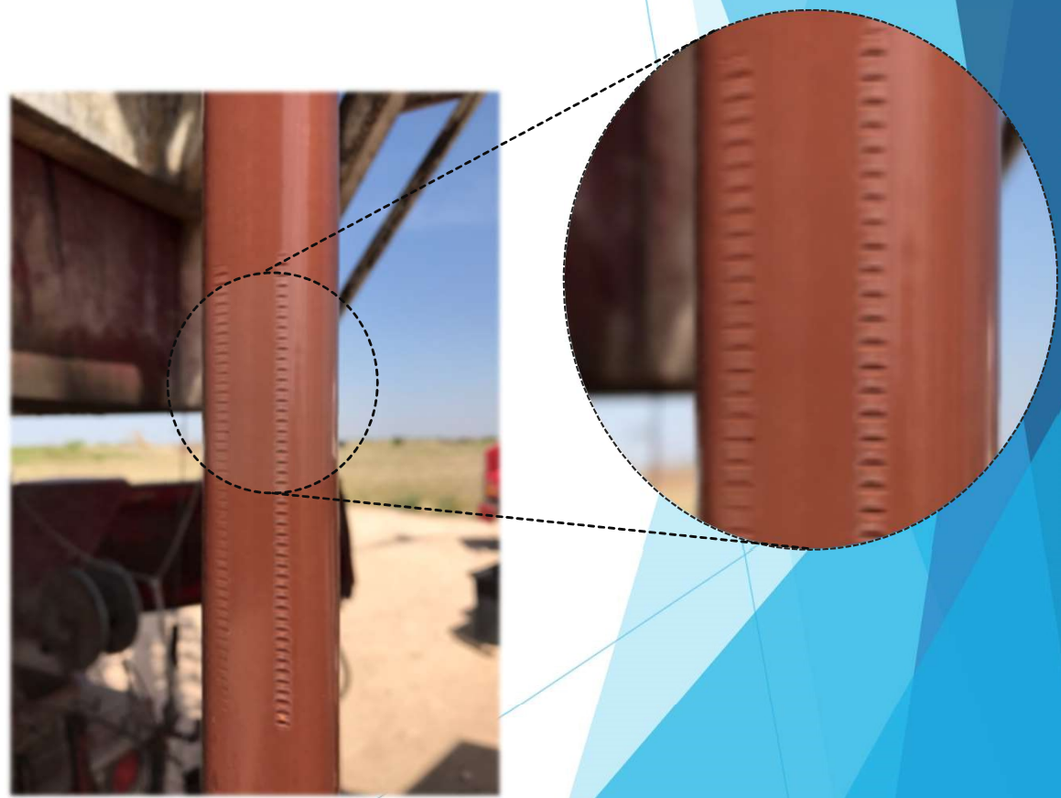
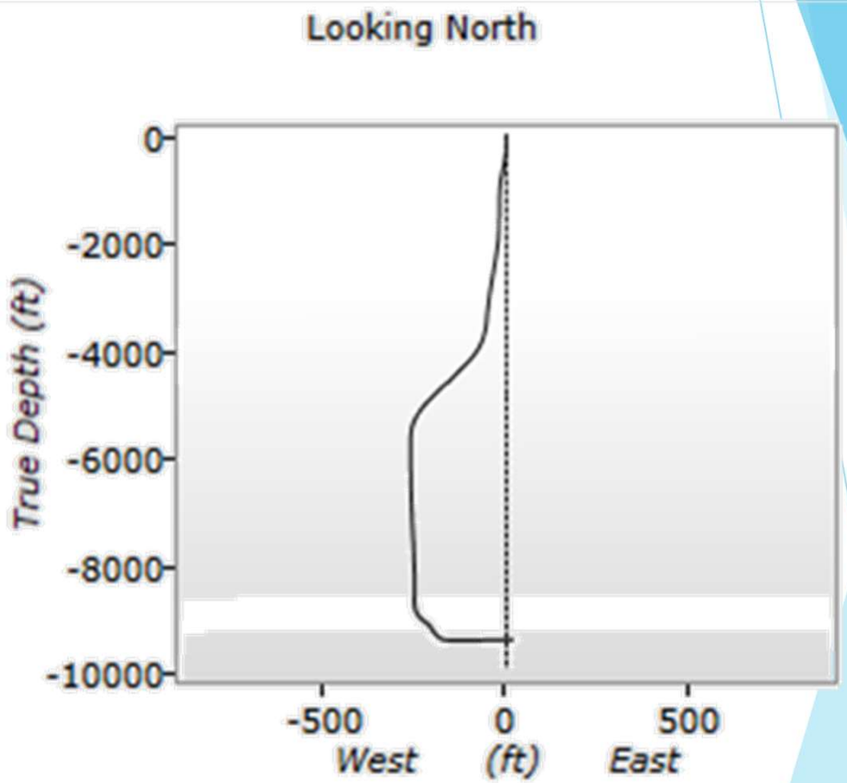
- Dual layer epoxy coating is specifically made with the intention of ‘pressing’ the outer layer while maintaining the inner layer intact for corrosion/wear protection.
- Specialized (friction-style) gripper pads are used for installation.
- Grippers are steel vs standard aluminum based grippers.



DESIGN COMPARISON PARAMETERS

SN @ 9,175’ in 35° tangent.

- Max Production @ 100 PIP
- Specific Gravity of fluid – 0.434
- Any pumping unit, pump and sucker rod string combination.
- Industry accepted coefficient of friction for chosen system.



CRITICAL PARAMETER COMPARISON

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		SUCKER ROD PUMPING SYSTEMS [SRPS]	
		SURFACE UNIT	
		RM 912-427-192	Long Stroke 1150
DESIGN & PRODUCTION	Barrels of Fluid per Day	392	848
	Pump Intake Pressure (psi)	100	100
	Pumping Speed (SPM)	7.95	4.29
	Surface Stroke Length	192	366
	Downhole Stroke Length	188	335
	Rod Type & Taper	Steel & Fiberglass Rods w/Guides	Continuous Rod w/Lined Tubing
	Pump Size	1.5" Insert	2.25" Tubing Pump
TECHNICAL OUTPUT	Motor HP (horsepower)	100 HP	125 HP
	Motor Loading (%)	76%	78%
	Balanced Gear Reducer Load (%)	97%	74%
	Structural Loading (%)	75%	94%
	Max Rod Loading (%)	89%	92%
	Days to 1 Million Cycles	87	162

FIELD TRIALS – NEW MEXICO #1

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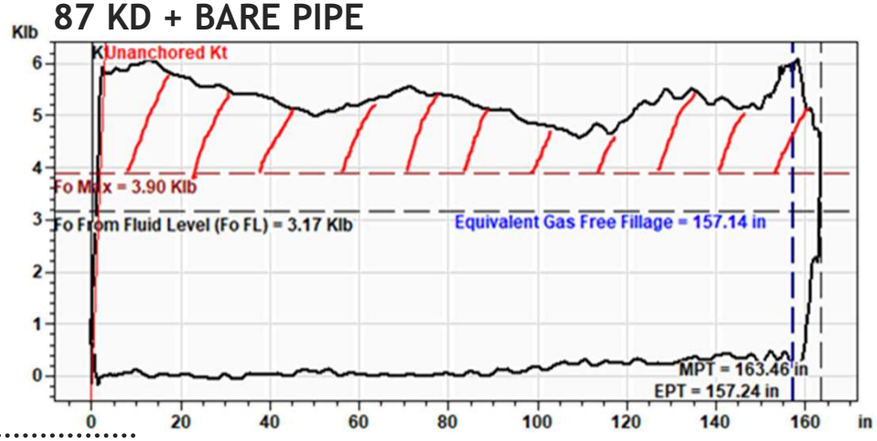
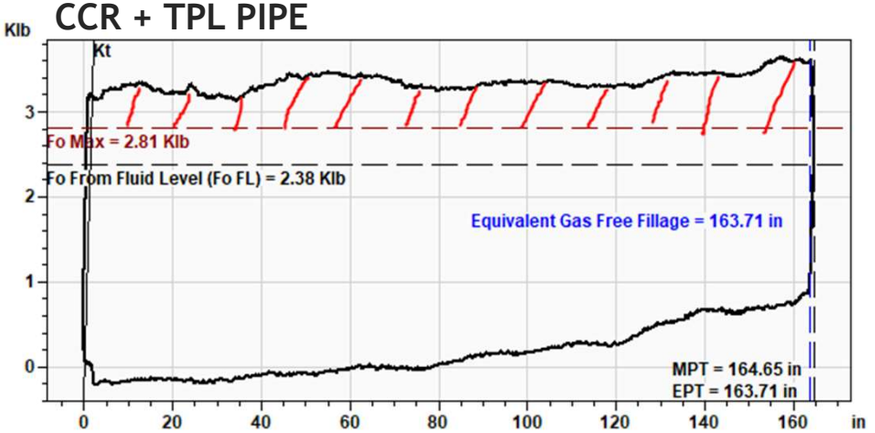
PUMP CARD BEFORE PHP = 14.2
87 KD + BARE PIPE



PUMP CARD AFTER PHP = 9.1
CCR + TPL PIPE



	Conventional design	Calabar + Line Pipe	*Comments*
PPRL	17,346	12,194	***29% lower***
MRPL	5,007	4,300	***Lighter string***
POLISHED ROD (HP)	17.2	9.2	***47% lower***
STRUCTURE LOAD	47.5%	33%	***30% lower***
D.H. FRICTION (LBS)	2,100	780	***63% lower***
D.H. PUMP STROKE (IN)	163.46	164.65	***1% gain***
ROD LOADING	90%	42%	***53% lower***
PIP	303psi	243psi	***60psi lower***

SUMMARY

The presentation and data have clearly shown how the proper design and engineering of high volume SRPS utilizing the aforementioned artificial lift technologies, Ultra Long Stroke Units matched with Thermoplastic Lined tubing strings and Epoxy Coated Continuous Sucker Rod string can greatly expand the operating range of SRPS, outperforming ESP's at depths and fluid volumes once thought "UNPUMPABLE".

***Thank you very much for your interest*.**

ACKNOWLEDGEMENTS

- We'd like to thank Weatherford and Western Falcon for providing technical information for the presentation.
- We'd like to thank Spur for allowing us to use dyno data from the Custer State well.
- We'd like to thank Lynn Rowlan with Echometer for his time and teaching in helping us better understand the dyno data.
- We'd like to thank the ALRDC for allowing us the opportunity and venue to give this presentation.

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