Artificial Lift R&D Council

Unconventional Results with Conventional Long Stroke Rod Lift Systems

A Study of Design Process and Results Produced in Various Applications

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ALRDC Artificial Lift Workshop
February 28th – March 3rd, 2022

Overview

- Technology Background
- Application 1
- Application 2
- Conclusions
- Acknowledgments and Questions

Technology Background

- C2560-500-320

- 320”, 275”, 234”, 193”
- 1 - 6.5 SPM

- Double reduction gearbox
- Pressed crank arms
- Multi-jack bolt tensioners
- LWM 2.0 controller

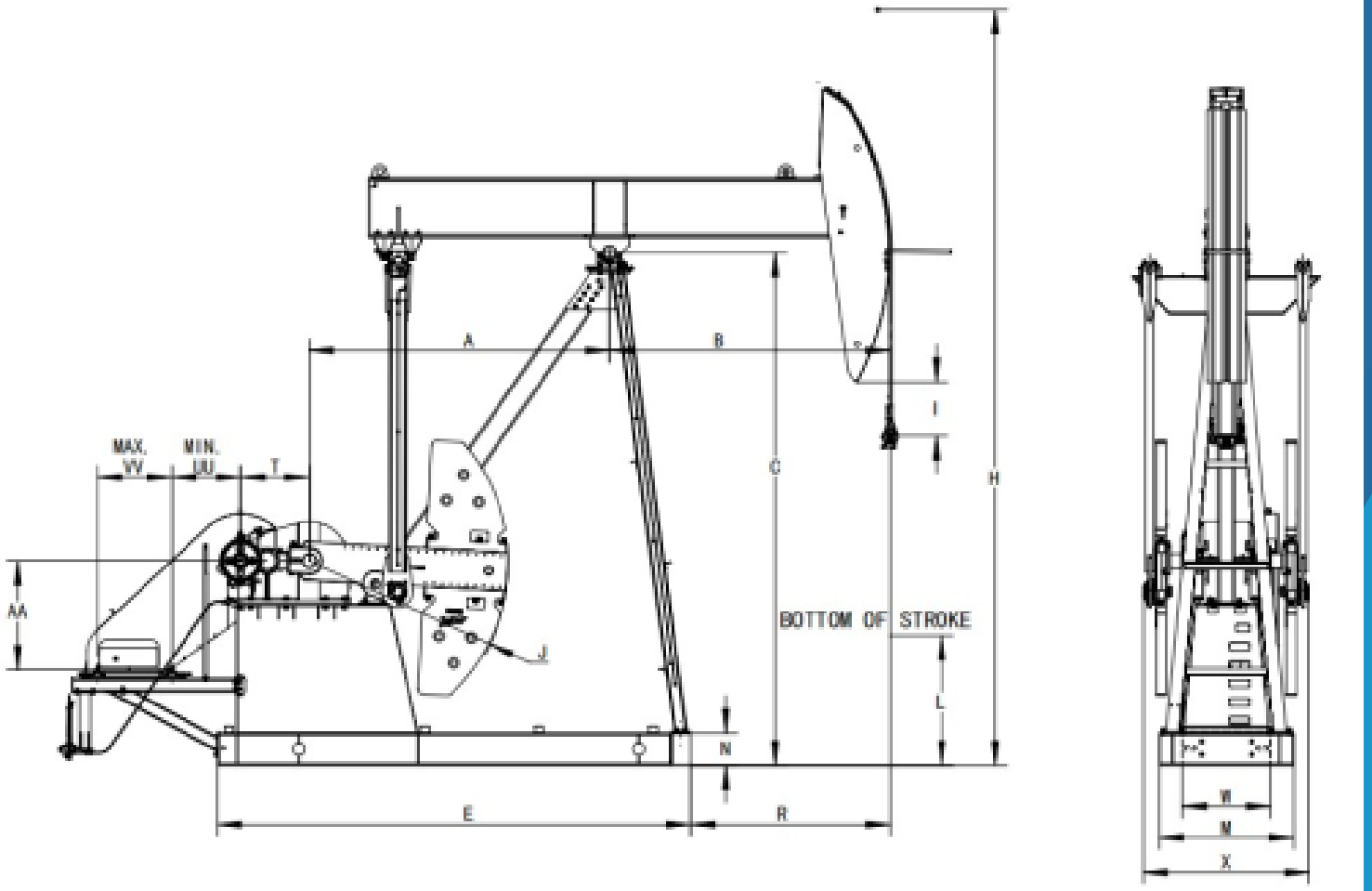
Technology Background

- Maintenance
  - Field personnel preferred
  - Workovers
  - Reduced failure rates

- Safety & environment
  - Reduced spill
  - Unit commonality

Technology Background

- Flexibility in design
  - Stroke length range
  - Stroke speed versatility
- Remove need for other artificial lift methods
  - Convert to beam earlier
  - Reduce runs or entirely skip alternative lift methods
  - Single artificial ALS



Design Process

- Client goals
  - Production targets
  - Operational initiatives
  - Current concerns
- Factors
  - Well characteristics
  - Frequent failures
  - Equipment preferences
- Predictive design software
  - Achieve client goals
  - Respect component limits
  - Multiple scenario iterations
- Application
  - Gather data
  - Assess performance
  - Optimize system design

Application #1
Operator 4 – Well B

- Targets
  - Production = 500 bpd
  - Operation = single unit
- Previous AL: ESP
- 2nd crank hole
- Hybrid 87 taper w/ 1.25” FG
- 1.75” insert pump
- SN = 9900’
- Desander

INPUT DATA

Strokes per minute:	7	Pump int. pr. (psi):	300
Run time (hrs/day):	24.0	Fluid level	
Tubing pres. (psi):	50	(ft over pump):	662
Casing pres. (psi):	50	Stuf.box fr. (lbs):	100
		Pol. rod. diam.	1.75"

Fluid Properties

Water cut:	50%
Water sp. gravity:	1.185
Oil API gravity:	41.0
Fluid sp. gravity:	1.0026

Motor & Power Meter

Power meter	Detent
Elect. cost:	$.06/KWH
Type:	NEMA D

Pumping Unit:Lufkin

API Size:C-2560-500-320 (Unit ID CUSTOM)	
Crank hole number:	# 2 (out of 4)
Calculated stroke length (in):	275.9
Crank rotation with well to right:	CCW
Max. cb moment (M in-lbs):	Unknown
Structural unbalance (lbs):	-5098
Crank offset angle (degrees):	0.0

Tubing And Pump Information

Tubing O.D. (in):	2.875	Upstr. rod-fl. damp. coeff.:	0.100
Tubing I.D. (in):	2.441	Dnstr. rod-fl. damp. coeff.:	0.100
Pump depth (ft):	9910	Tub.anch.depth (ft):	9860
Pump conditions:	Full		
Pump type:	Insert	Pump vol. efficiency:	90%
Plunger size (in):	1.75	Pump friction (lbs):	200.0

CALCULATED RESULTS

Production rate (bfpd):	646	Peak pol. pod load (lbs):	36309
Oil production (BOPD):	323	Min. pol. rod load (lbs):	8021
Strokes per minute:	7	MPRL/PPRL:	0.221
System eff. (Motor->Pump):	34%	Unit struct. loading:	73%
Permissible load HP:	210	PRHP / PLHP:	0.42
Fluid load on pump (lbs):	9756	Buoyant rod weight (lbs):	15098
Fluid level tvd (ft from surface):	9223	N/No: .427 , Fo/SKr: .386	
Polished rod HP:	87.2		
Required prime mover size (speed var. not included)	BALANCED (Min Torq)		

NEMA D motor:	152 HP
Single/double cyl. engine:	130 HP
Multicylinder Engine:	152 HP
Torque analysis and electricity consumption	BALANCED (Min Torq)
Peak g'box torq.(M in-lbs):	1880
Gearbox loading:	73.5%
Cyclic load factor:	1.324
Max. cb moment (M in-lbs):	3653.63
Counterbalance effect(lbs):	22842
Daily electr.use (Kwh/Day):	2340
Monthly electric bill:	$4282
Electr.cost per bbl fluid:	$0.217
Electr.cost per bbl oil:	$0.435

Tubing, Pump And Plunger Calculations

Tubing stretch (in):	.0
Prod. loss due to tubing stretch (bfpd):	0.0
Gross pump stroke (in):	287.3
Pump spacing (in. from bottom):	78.1
Minimum pump length (ft):	40.1
Recommended plunger length (ft):	6.0

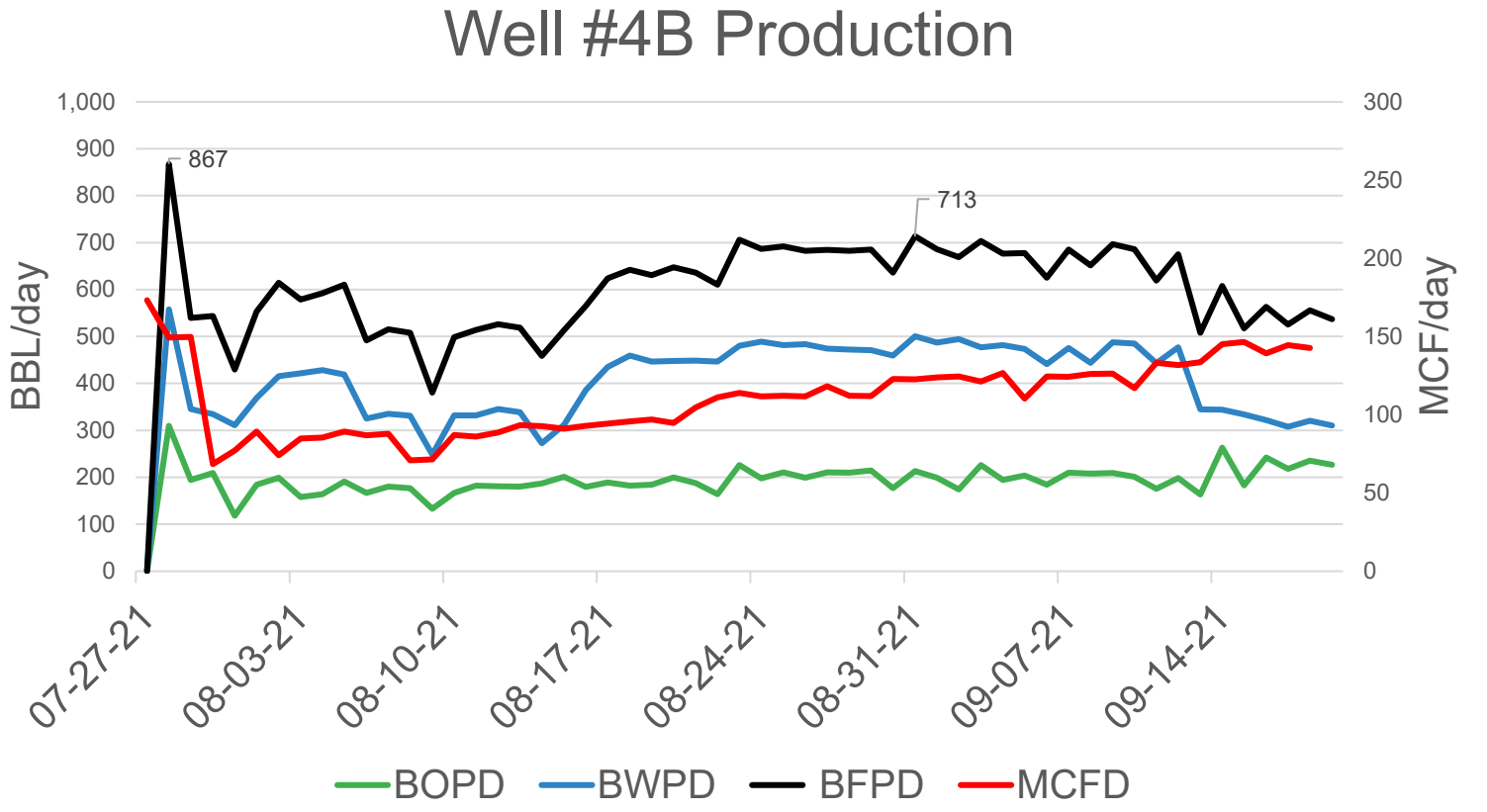
Rod string design

Rod string stress analysis (service factor: 1)

Diameter (in)	Rod Grade	Length (ft)	Min. Ten. Str. (psi)	Fric. Coeff	Stress Load %	Top Maximum Stress (psi)	Top Minimum Stress (psi)	Bot. Minimum Stress (psi)	# Guides/Rod
+ 1	N90 (T/2.8)	300	120000	0.25	98.3%	46103	10341	9329	3
+ 1.22	JC FSR 200	2200	N/A	0.25	83.9%	30056	6155	5001	5
+ 1.22	JC FSR 200	1800	N/A	0.2	74.7%	26545	4379	3836	0
+ 1.22	JC FSR 200	2475	N/A	0.25	68.4%	23766	2792	3749	5
+ 1	N90 (T/2.8)	1350	120000	0.25	64.7%	30476	4632	3220	3
0.875	N90 (T/2.8)	1150	120000	0.25	66.3%	29927	2586	1455	3
@ 1.625	K (API. SB)	625	90000	0.2	76.8%	16804	-701	-96	0

Application #1
Operator 4 – Well B

- Increased production
  - Better analytics than systems utilizing other unit geometries
  - No production dip when changing ALS
- Reduced operating cost
  - Save on ESP runs
  - Avoid the unit shuffle



Application #2
Operator 3 – Well B

- Targets
  - Production = maximum
  - Operation = no ESP
- Previous AL: None
- 1st crank hole
- Steel 87 taper
- 2.75” tubing pump
- SN = 5000’
- Desander

INPUT DATA

Strokes per minute:	4.6	Fluid level	
Run time (hrs/day):	24.0	(ft from surface):	1135
Tubing pres. (psi):	150	(ft over pump):	3865
Casing pres. (psi):	75	Stuf.box fr. (lbs):	100
		Pol. rod. diam. 1.5"	

Fluid Properties

Water cut:	68.3%
Water sp. gravity:	1.21
Oil API gravity:	43.0
Fluid sp. gravity:	1.0835

Motor & Power Meter

Power meter	Detent
Elect. cost:	$.06/KWH
Type:	NEMA D

Pumping Unit:Lufkin Longstroke

API Size:C-2560-500-320 (Unit ID CUSTOM)

Crank hole number:	# 1 (out of 4)
Calculated stroke length (in):	320.4
Crank rotation with well to right:	CCW
Max. cb moment (M in-lbs):	Unknown
Structural unbalance (lbs):	-5098
Crank offset angle (degrees):	0.0

Tubing And Pump Information

Tubing O.D. (in):	2.875	Upstr. rod-fl. damp. coeff.:	0.100
Tubing I.D. (in):	2.441	Dnstr. rod-fl. damp. coeff.:	0.100
Pump depth (ft):	5000	Tub.anch.depth (ft):	4900
Pump conditions:	Full		
Pump type:	Tubing	Pump vol. efficiency:	90%
Plunger size (in):	2.75	Pump friction (lbs):	200.0

CALCULATED RESULTS

Production rate (bfpd):	1110	Peak pol. pod load (lbs):	24441
Oil production (BOPD):	352	Min. pol. rod load (lbs):	6841
Strokes per minute:	4.6	MPRL/PPRL:	0.28
System eff. (Motor->Pump):	21%	Unit struct. loading:	49%
Permissible load HP:	134.3	PRHP / PLHP:	0.27
Fluid load on pump (lbs):	6306	Buoyant rod weight (lbs):	11480
Fluid level tvd (ft from surface):	1135	N/No: .093 , Fo/SKr: .055	
Polished rod HP:	36.6		
Required prime mover size (speed var. not included)	BALANCED (Min Torq)		
NEMA D motor:	75 HP		
Single/double cyl. engine:	60 HP		
Multicylinder Engine:	75 HP		
Torque analysis and electricity consumption	BALANCED (Min Torq)		
Peak g'box torq.(M in-lbs):	1386		
Gearbox loading:	54.2%		
Cyclic load factor:	1.383		
Max. cb moment (M in-lbs):	3217.46		
Counterbalance effect(lbs):	16539		
Daily electr.use (Kwh/Day):	858		
Monthly electric bill:	$1570		
Electr.cost per bbl fluid:	$0.046		
Electr.cost per bbl oil:	$0.146		

Tubing, Pump And Plunger Calculations

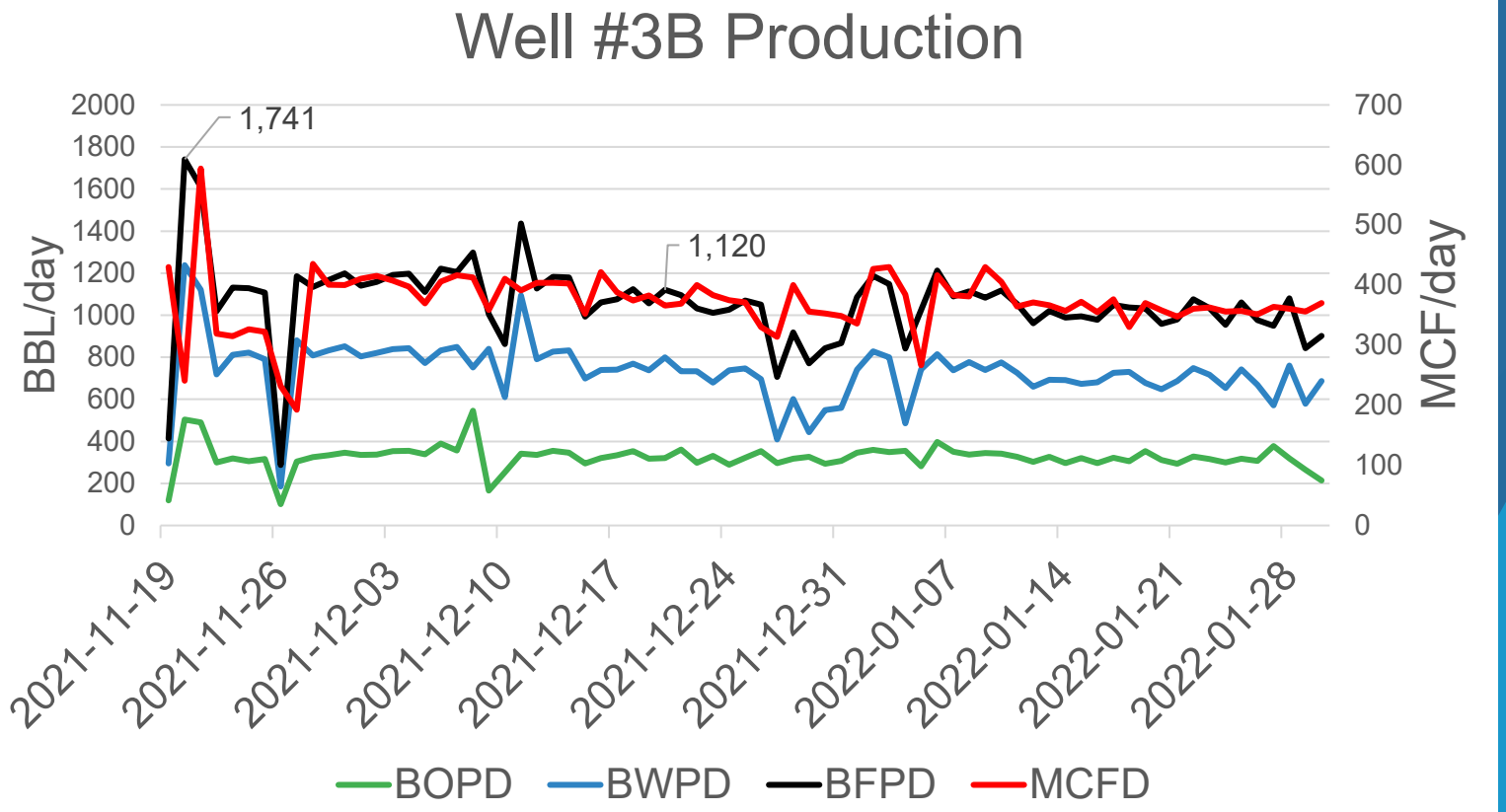
Tubing stretch (in):	.1
Prod. loss due to tubing stretch (bfpd):	0.5
Gross pump stroke (in):	304.2
Pump spacing (in. from bottom):	15.0
Minimum pump length (ft):	34.0
Recommended plunger length (ft):	3.0

Rod string design / **Rod string stress analysis (service factor: 1)**

Diameter (in)	Rod Grade	Length (ft)	Min. Ten. Str. (psi)	Fric. Coeff	Stress Load %	Top Maximum Stress (psi)	Top Minimum Stress (psi)	Bot. Minimum Stress (psi)	# Guides/Rod
+ 1	HA (T/2.8)	2200	140000	0.2	49.8%	30992	8837	4041	0
0.875	HA (T/2.8)	400	140000	0.3	45.9%	26340	4738	4259	6
0.875	HA (T/2.8)	1400	140000	0.2	40.9%	23026	3456	1274	0
+ 1	HA (T/2.8)	1000	140000	0.3	23.0%	11576	71	-255	4

Application #2
Operator 3 – Well B

- Avoid ESP
  - Save capital expense
  - Reduce operating costs



Conclusions

- Convert to beam sooner
- Exceeded production goals
- Avoid unit shuffle
- Reduced maintenance
- Lower capital and operating costs

Acknowledgements and Questions

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