

# Value Proposition of Polyketone Liners & Continuous Rod in Deviated Wells

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# Deviated Rod Pumped Failure Methods

- Abrasive Wear
  - Rod on tubing wear
  - Deviation
  - Buckling
  - Enhanced by presence of solids
- Corrosive Wear
  - Chemical reaction on surface of tubing
  - Corroded material worn away, allowing for corrosion to attack again

# Potential Benefits of Thermoplastic Liners

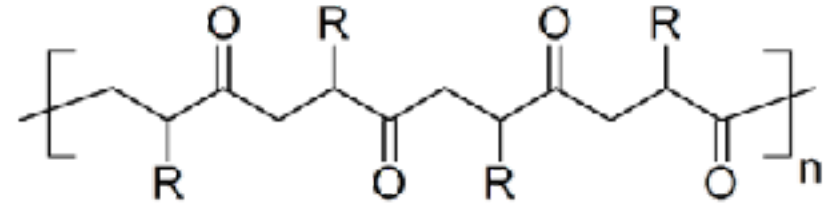
- Prevents rod on tubing contact, eliminating steel on steel wear
- Does not allow corrosive fluids to continuously erode tubing
- Protects tubing from exposure to abrasive solids
- Holiday-free to prevent localized corrosion attack



# Thermoplastic Liner Resin Options

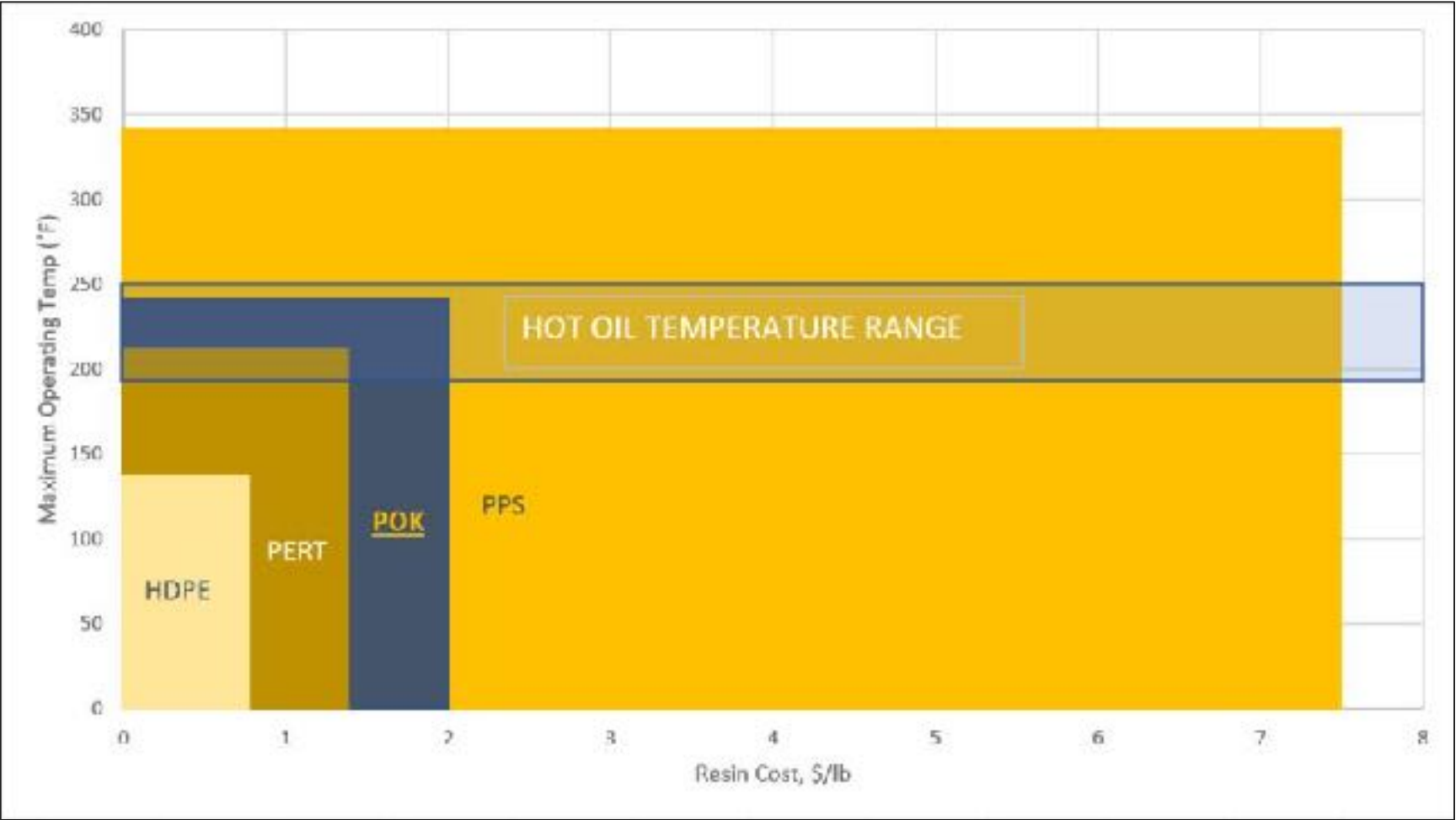
General Specifications					
Material Type	Max Temp.	Dimensions	H <sub>2</sub> S	CO <sub>2</sub>	Cost
HDPE	140° F	2 3/8" - 4 1/2"	2%	10%	\$
HDPE - Modified	210° F	2 3/8" - 4 1/2"	2%	10%	\$\$
<b>POK - Modified</b>	<b>240° F</b>	<b>2 3/8" - 4 1/2"</b>	<b>5%</b>	<b>20%</b>	<b>\$\$</b>
PPS - Modified	340° F	2 3/8" - 4 1/2"	5%	20%	\$\$\$\$
PEEK	500° F	2 3/8" - 4 1/2"	5%	20%	\$\$\$\$\$

# Polyolefin Ketone Resin (POK)



- Unique engineering plastic with a carbon-only backbone
- Highly crystalline with a compact crystal structure
- Stable at high temperatures
- Has excellent abrasion/chemical/fuel resistance
- Gas barrier properties
- Physical and chemical properties make the resin well suited for downhole applications

# Resin Working Temperature vs Cost



# Potential Benefits of Continuous Rod

- Side Load Distributed over Entire String, Not on Coupling Alone
- No Reduced Flow Area around Couplings
  - Reduce breakout of corrosive elements due to turbulent flow around couplings and rod guides
  - Potentially increase production with less flow restriction in the tubing
- Eliminate Care & Handling Failures and Improper Makeup
- Fast, Easy Installation

# Continuous Rod Installation





# OXY Trial Parameters

- OXY began experimenting with a mixture of continuous rod and thermoplastic liners on very high failure frequency wells Q4 2016
- Initial pilot consisted of 6 wells, with various configurations
- Longest running wells used conventional sucker rod with thermoplastic liners
- More recent installations included both thermoplastic liners and continuous rod
- Failure frequency on the six wells prior to trial was 2.95 failures/well/year

# Trial Wells

- Six well pilot in South Delaware Basin Asset
  - Anna Katherine 23-1 installed 9/29/2016 with mixture of PPS and POK
  - Houser 36-2 installed 11/17/2016 with conventional stick rod
  - Perry State 264-3 installed 12/8/2016
  - Lyda 9-4 installed 2/14/2017
  - Toyah Lake installed 3/23/2017
  - Betty Lou 1607 installed 7/13/2017
- Failures primarily due to wear
  - Side loads near 200 lbs
  - Likely due to buckling in many instances
  - Accelerated by mild corrosion

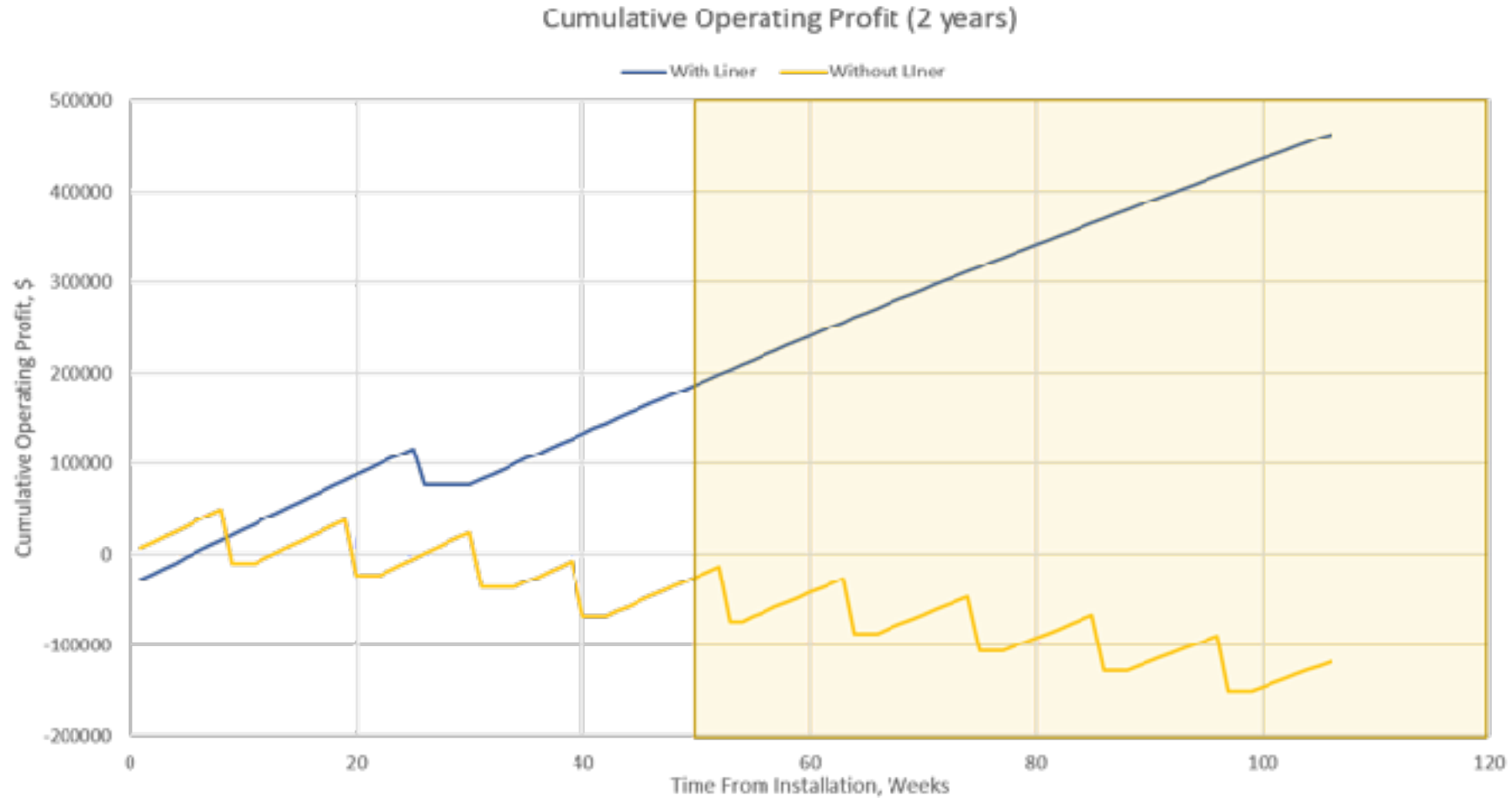
# Case Study 1 – Houser 36-2

- Delaware Basin, Reeves County, Texas
- MTBF of ~60 days on tubing prior to installing thermoplastic liner
- POK liner installed from 4000ft to 10,000ft
- Bare tubing ran above 4000ft
- Run in the hole with conventional rods
- Currently operating 323 days without tubing failure (was down 32 days due to rod failure)

# Case Study 1 – Cost Analysis

• Base tubing workover cost	\$60,000
• Liner Cost per Foot	\$5.73
• Oil Price per Barrel	\$40
• Oil Production Rate (BPD)	30
• Lifting Cost per Barrel	\$10
• Annual Production Decline Rate	10%
• Downtime per Failure (days)	21
• Previous MTBF (months)	2
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• Failures Saved to Date	4.38
• Lost Production Revenue per Failure	\$18,900
• Total Savings per Failure	\$78,900
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• <b>Total Savings Less Investment to Date</b>	<b>\$311,465</b>
• <b>ROI to Date</b>	<b>906%</b>

# Case Study 1 – Cumulative Operating Profit



\* Annual Decline Rate = 10%, Annual Discount Rate = 7%

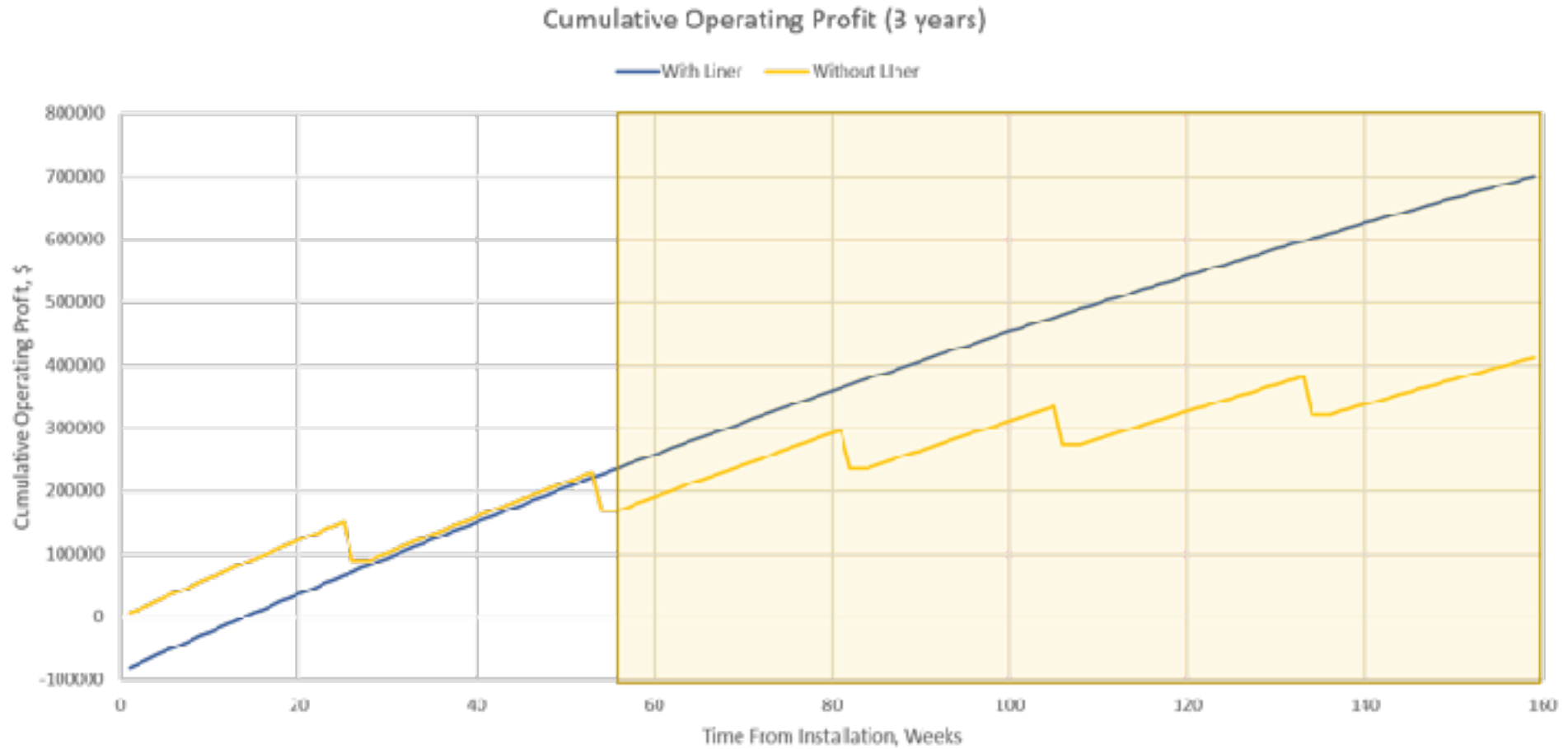
# Case Study 2 – Anna Katherine 23-1

- Delaware Basin, Reeves County, Texas
- MTBF of 6 months on tubing prior to installing thermoplastic liner
- POK liner installed from surface to 6,500ft
- PPS liner installed from 6,500ft to 10,000ft
- Run in the hole with continuous rods
- Currently operating for 404 days without a failure

# Case Study 2 – Cost Analysis

• Base tubing workover cost	\$60,000
• Liner Cost per Foot (blended)	\$7.57
• Initial Continuous Rod Investment	\$20,000
• Oil Price per Barrel	\$40
• Oil Production Rate (BPD)	30
• Lifting Cost per Barrel	\$10
• Annual Production Decline Rate	10%
• Downtime per Failure (days)	21
• Previous MTBF (months)	6
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• Failures Saved to Date	1.244
• Lost Production Revenue per Failure	\$12,600
• Total Savings per Failure	\$72,600
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• <b>Total Savings Less Investment to Date</b>	<b>\$12,486.67</b>
• <b>ROI to Date</b>	<b>15%</b>

# Case Study 2 – Cumulative Operating Profit



\* Annual Decline Rate = 10%, Annual Discount Rate = 7%



# Case Study 2 – ROI Sensitivity

- All variables remain constant except run-time
  - ROI after 30 additional days = 30%
  - ROI after 90 additional days = 61%
  - ROI after 180 additional days = 107%
  - ROI after 365 additional days = 201%
- All variables remain constant except oil price
  - ROI at \$45/bbl = 19%
  - ROI at \$50/bbl = 24%
  - ROI at \$55/bbl = 28%

# Trial Results to Date

- Early results on initial 6 well pilot indicate a decrease in failures from 2.95 failures/well/year to ~0.25 failures/well/year
- At this point, it is too early to tell whether continuous rod with lined tubing will be more effective than lined tubing alone, but the cost of continuous rod is comparable with conventional rod so investment is minimal
- Reducing failure rate by half would allow project to break even, which has already been accomplished in first 6 wells
- Current average run time on 6 well pilot is 313 days, which would equate to 1.12 failures/well/year if all 6 wells failed today
- Current savings of \$40,656 per well and an average ROI of 58%

# Other Ongoing Trials

- Continuous rod run in Reeves County, TX to a depth of 11,200 ft
- Continuous rod and Polyketone Thermoplastic Liner ran in two wells where pump is landed at 90° and 7000' MD in Irion County, TX
- Polyketone liner being run in SWD wells in same basin with OXY
- Around 20 wells now using Polyketone Thermoplastic Liner with operators in Permian Basin, Delaware Basin, and Uintah Basin
- 17 continuous rod installations with LRP continuous rod since January, 2017 and no failures to date

# Considerations to Improve ROI

- Investment cost for thermoplastic liner can be reduced by lining used tubulars
- Lost production value is more impactful for wells with high production or long lead times for workovers
- Continuous rod workover typically are quicker than conventional stick rod, which can reduce workover cost
- Combination of Coiled Rod & Thermoplastic Liners have the greatest impact on ROI
- For most applications, thermoplastic liner will break even before the first workover is avoided
- Continuous rod can have a positive ROI by increasing MTBF by as little as 30 days

# Acknowledgements

- Thank you to OXY for allowing us to present this data
- To all LPS customers who are participating in trials across multiple basins
- Co-workers for making this trial possible

# Questions?

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