



7° CONGRESO IAPEG
**Producción
y Desarrollo
de Reservas**

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Unconventional Energy - Gas Management with Electrical Submersible Pump (ESP) Systems in Shale Plays

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Unconventional Production with ESP (BES)

Characteristics

Reservoir

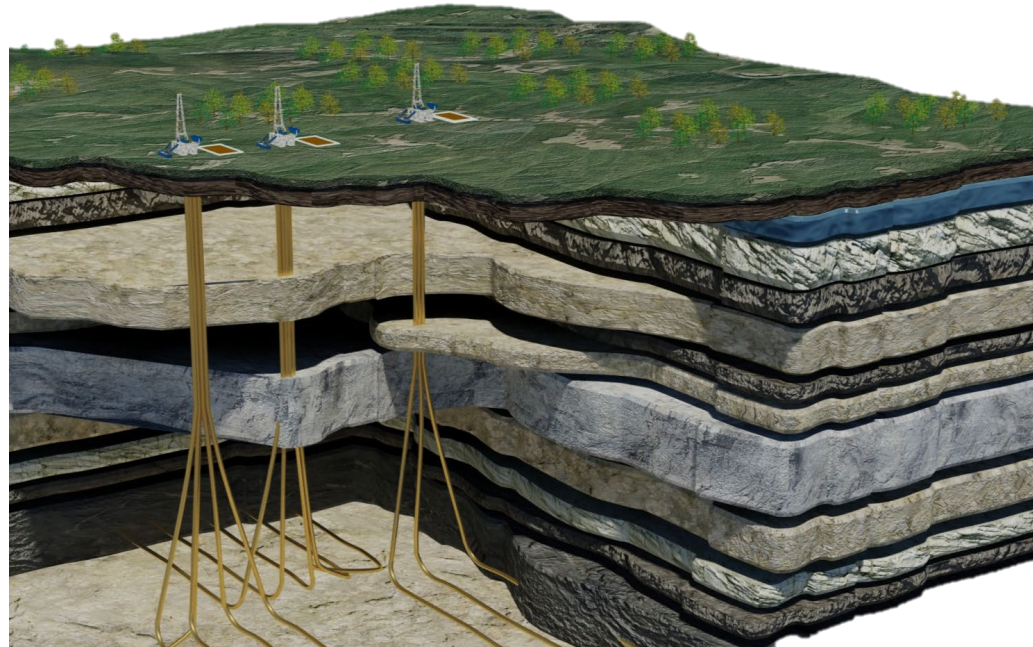
- Low Permeability
- Solution gas drive

Well Construction

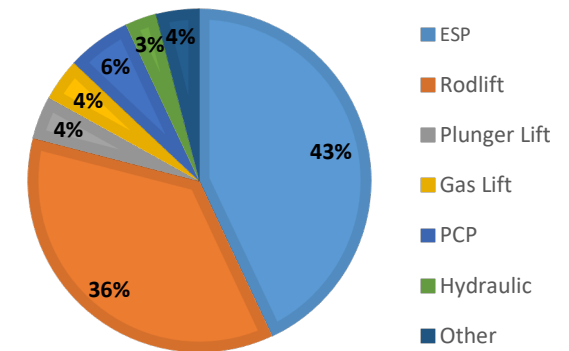
- Horizontal wells
- Multiple fracture stages
- Smaller, heavier casings

Challenges

- Gas handling
- Strong production decline
- Sand handling
- High deviations
- Casings sizes



MARKET SHARE OF ARTIFICIAL LIFT SYSTEMS

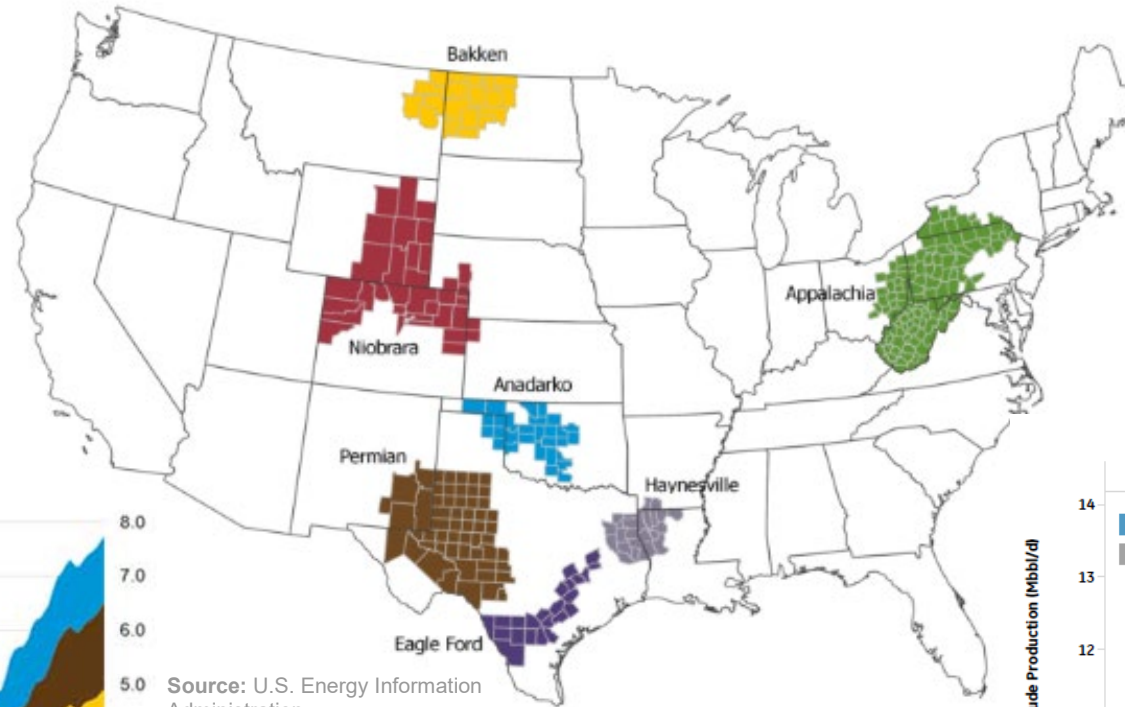


ESP (BES)

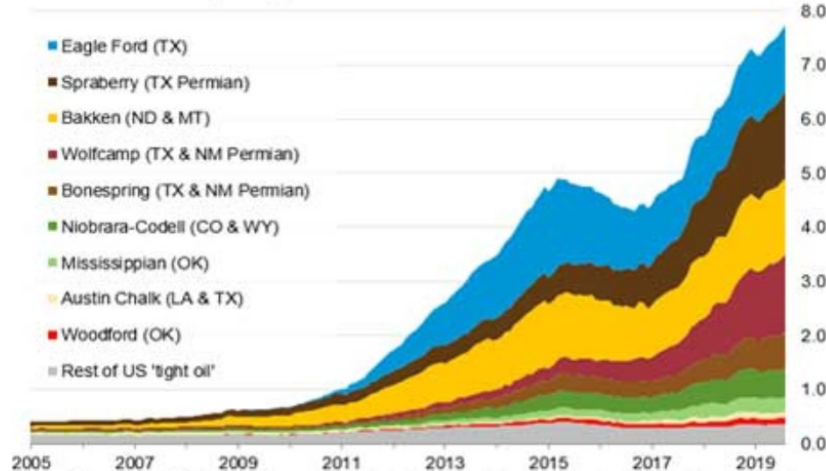
- ESP 43% of total ALS
- > 90% world production with ALS
- ~ 60% achieved with ESPs
- ESPs produce the highest flow rates

Unconventional Production with ESP (BES)

Shale Oil Production
60% of US Total Prod.
Permian Basin Major field
(> 4MM BOPD)

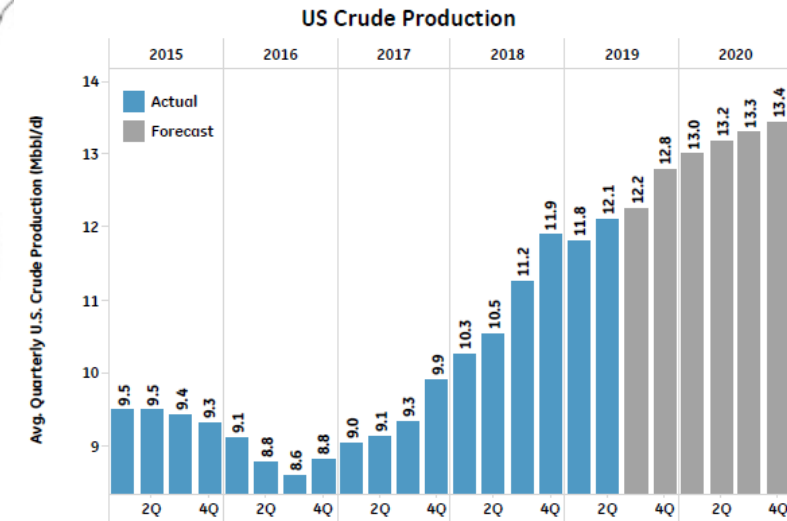


U.S. Production Record '18
>12MMBOPD - 2019 Actual
>13 MMBOPD - 2020 Est.



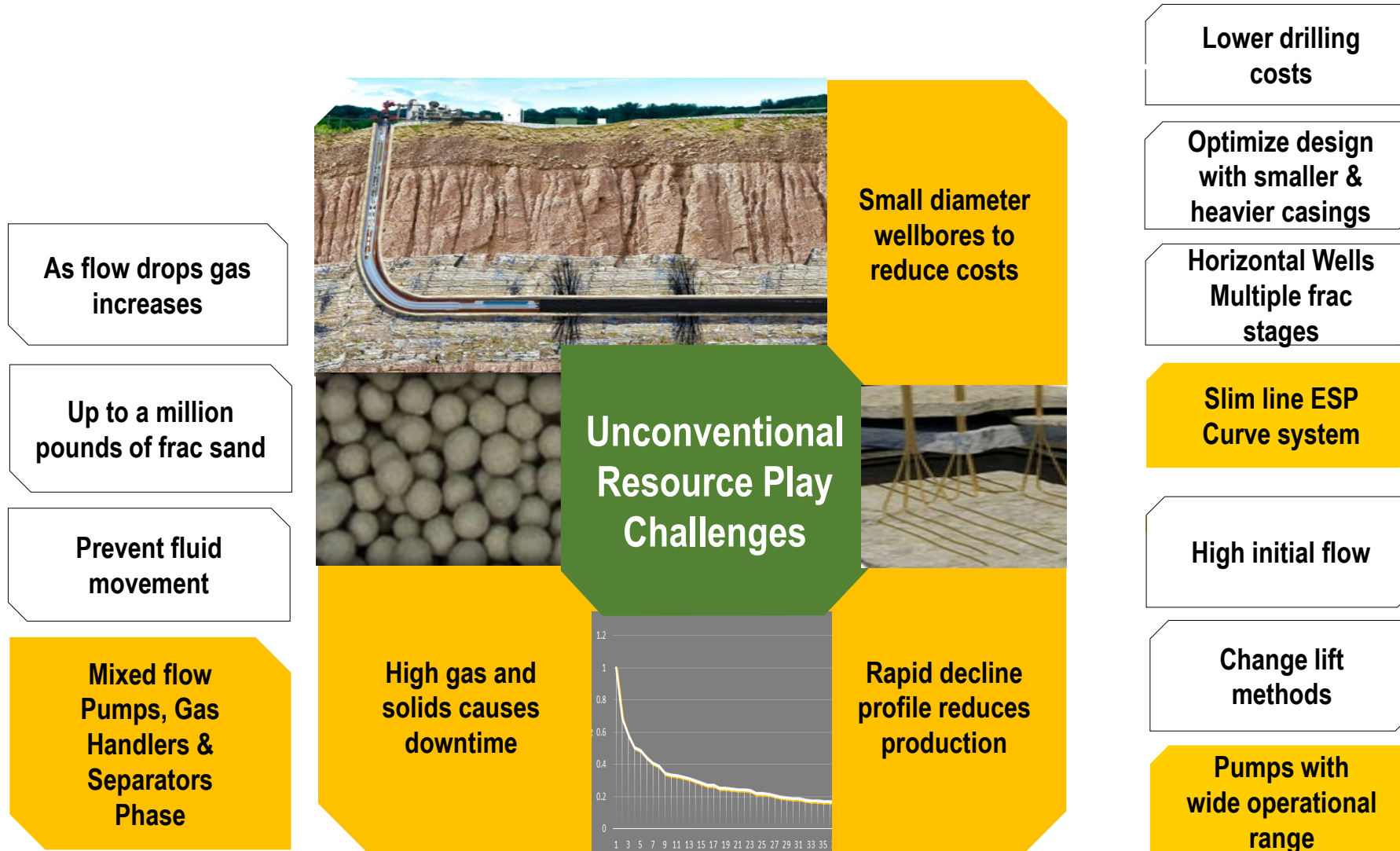
Source: U.S. Energy Information Administration

(2013 – 2018)
ESP Installs: 9897 (BH)
ESP Running: 3779 (BH)



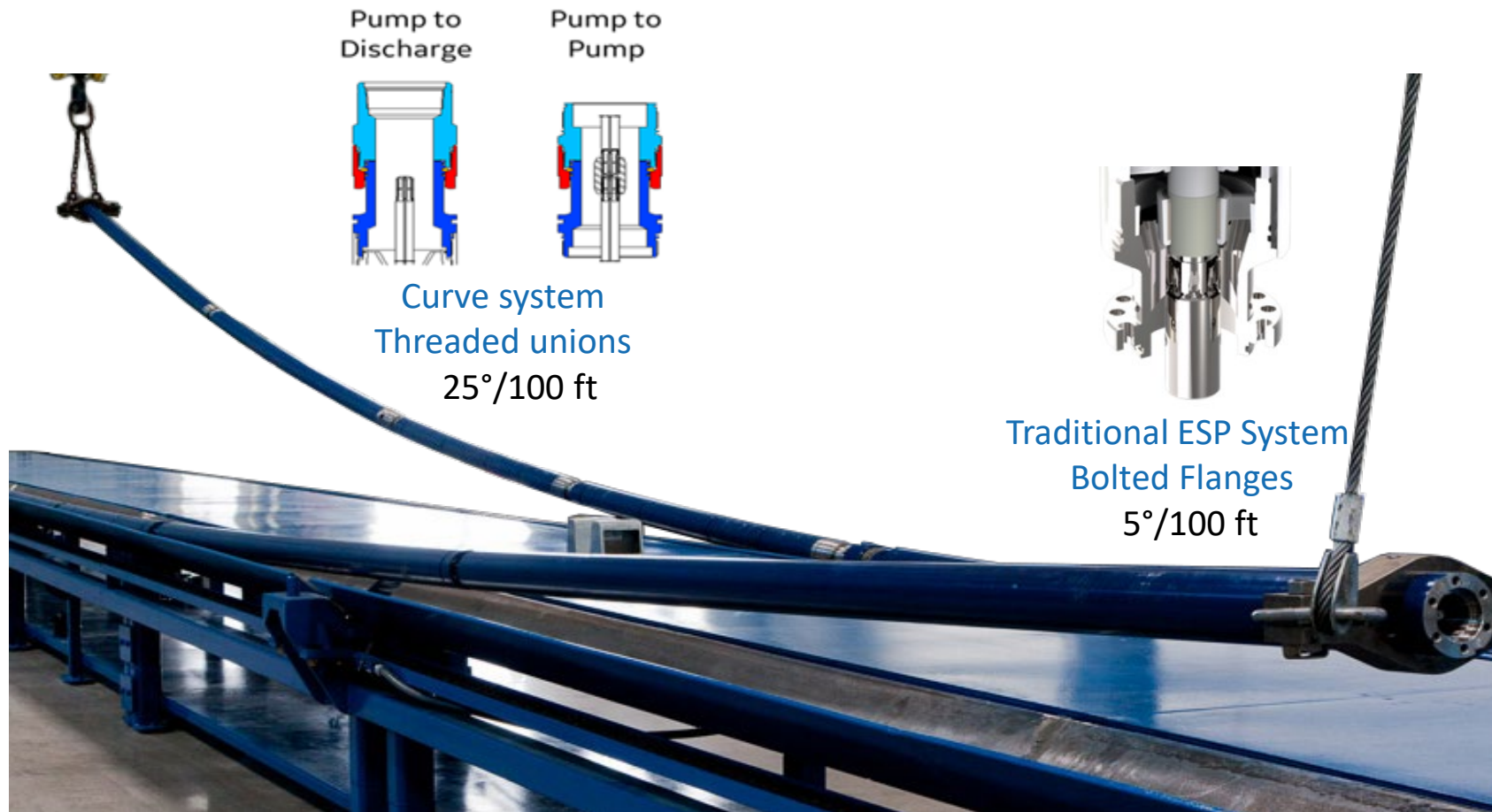
Source: EIA STEO August'19

Unconventional Production, Challenges and Solutions





Tight-radius ESP system for Deviated & Horizontal Wells

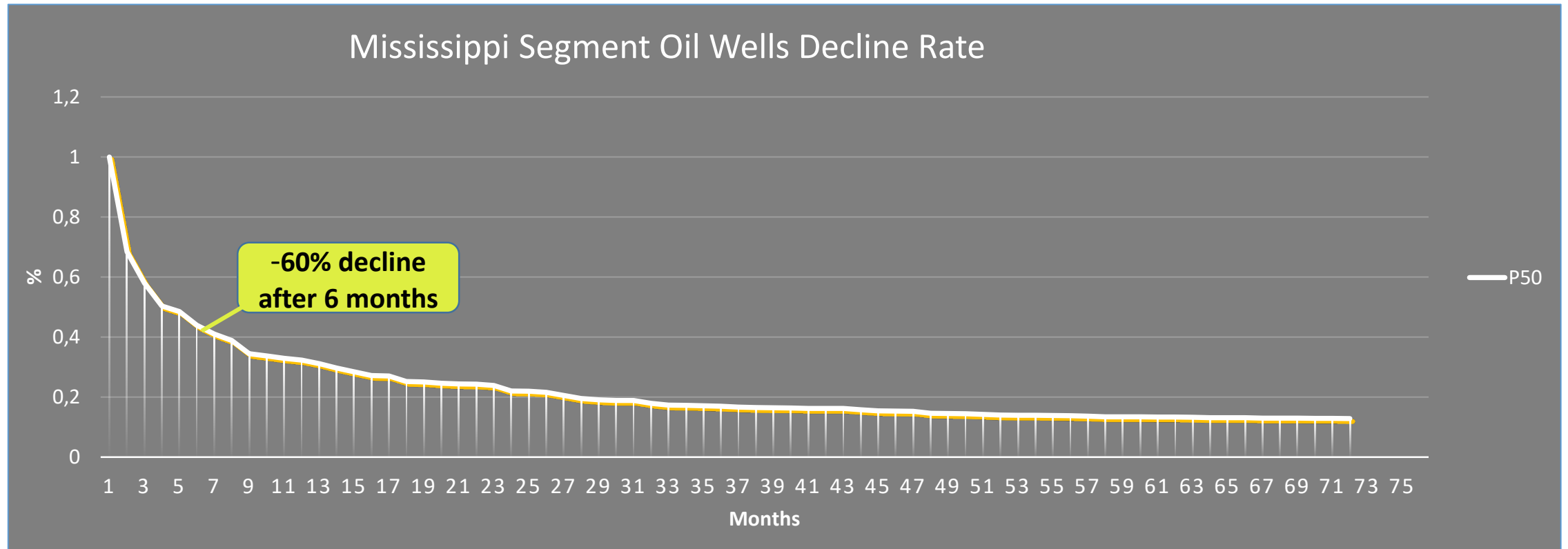


25°/100 ft deviation

- ✓ Sits deeper in the well to improve production
- ✓ Enhances reliability
- ✓ Lowers OPEX
- ✓ Speeds installation time by ~50%
- ✓ Provides greater tensile strength

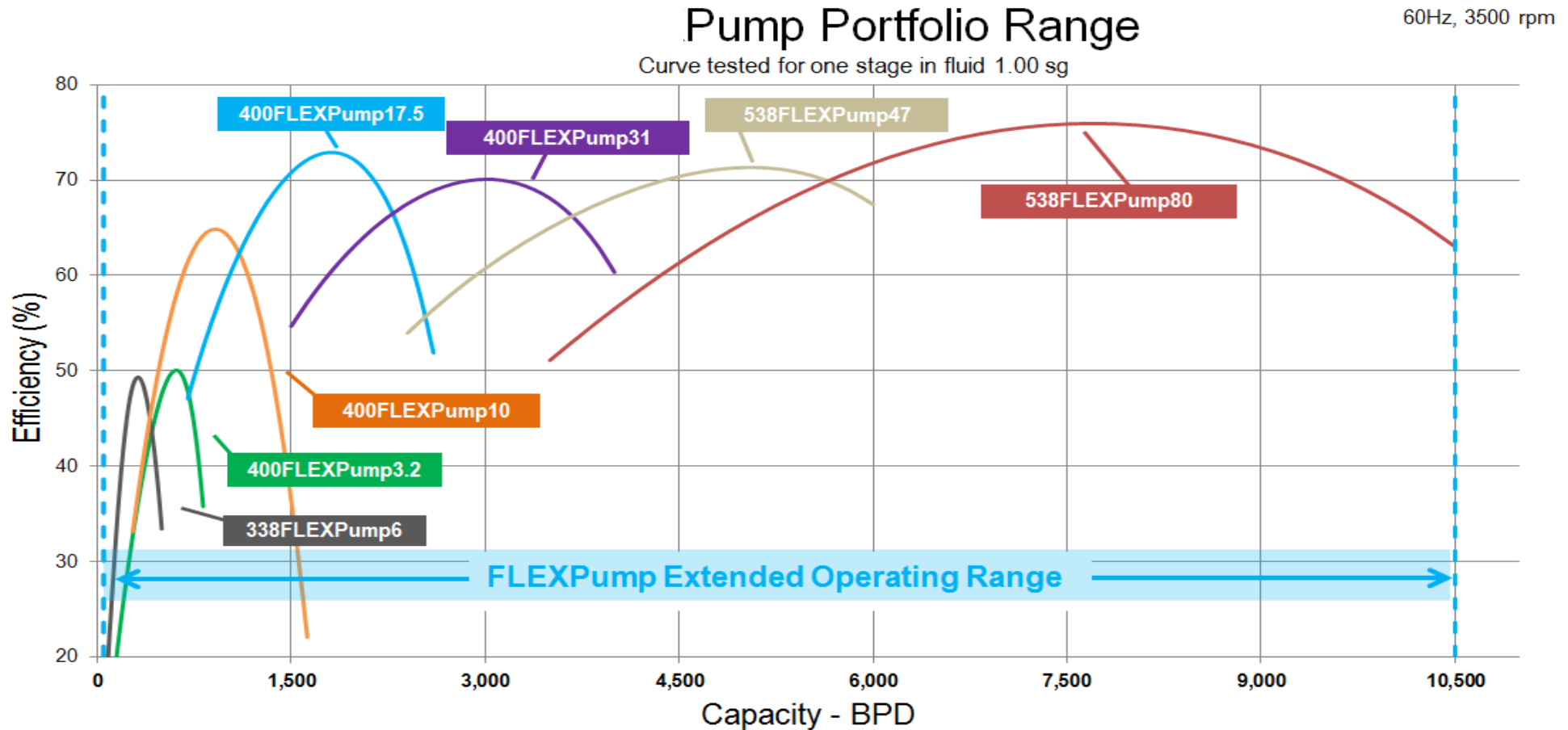


Strong Production Decline





Widest operating range with fewer pumps



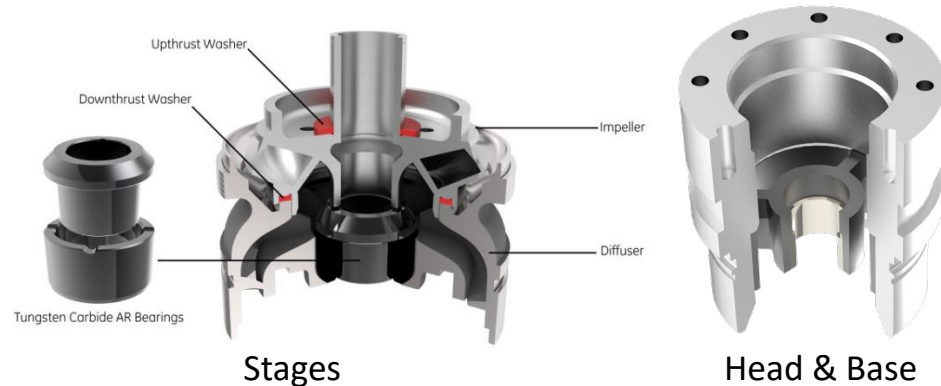


Abrasives - Mitigation

- Pump damage
- Stage erosion & abrasion
- Sand / Proppant
- Flow back



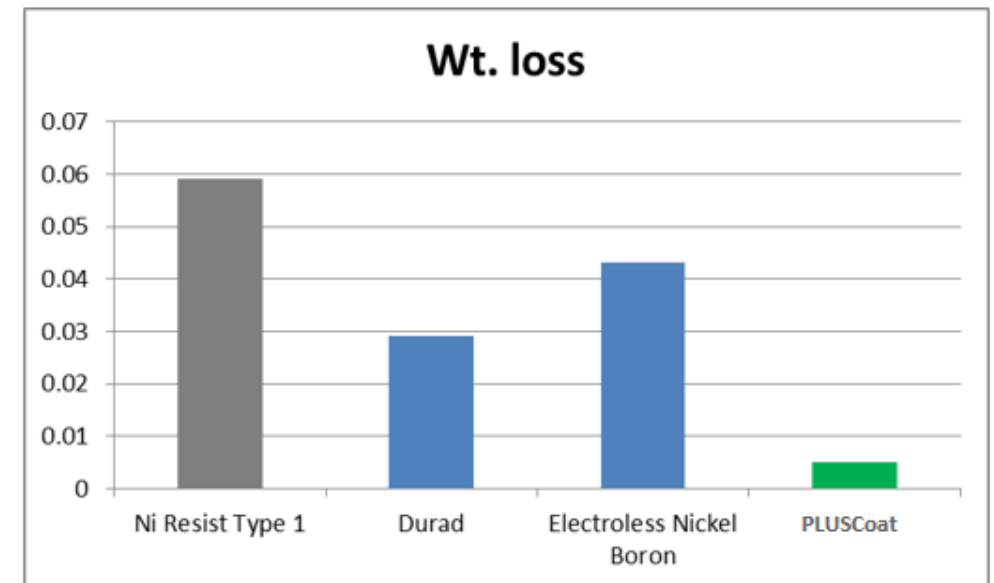
Tungsten Carbide (TC) bearings



Coatings

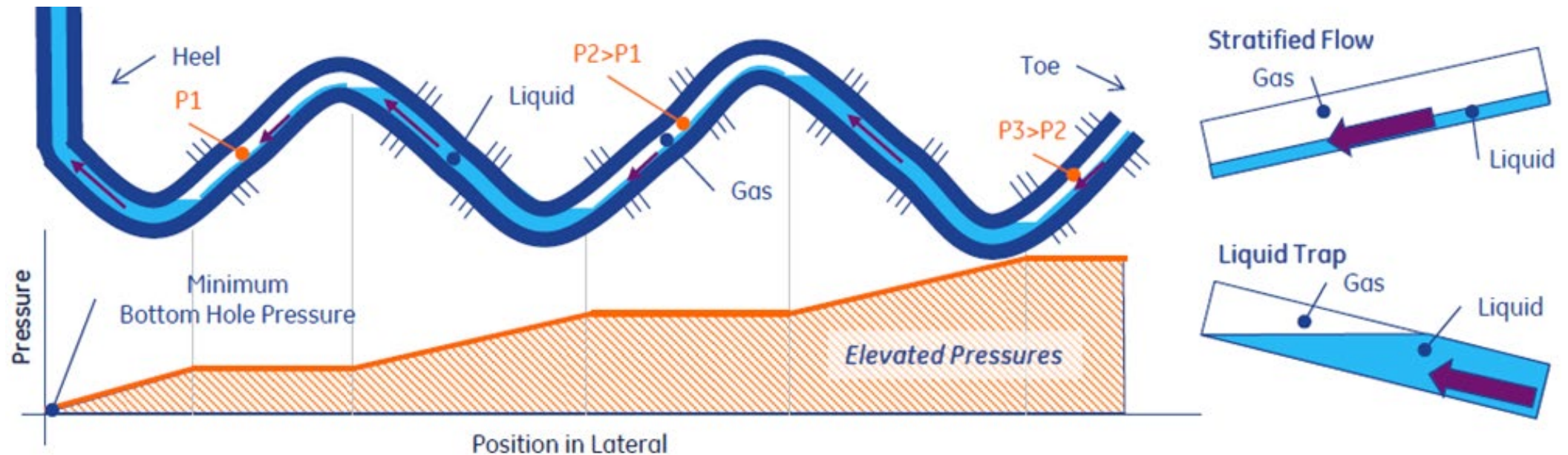


Abrasion Resistance





Gas Slugging



Challenges:

1. Trapped gas builds pressure until migration/ slugging.
2. Elevated wellbore pressures reduce inflow, reduce production rate



Gas Interference Mitigation

Phase Separation System

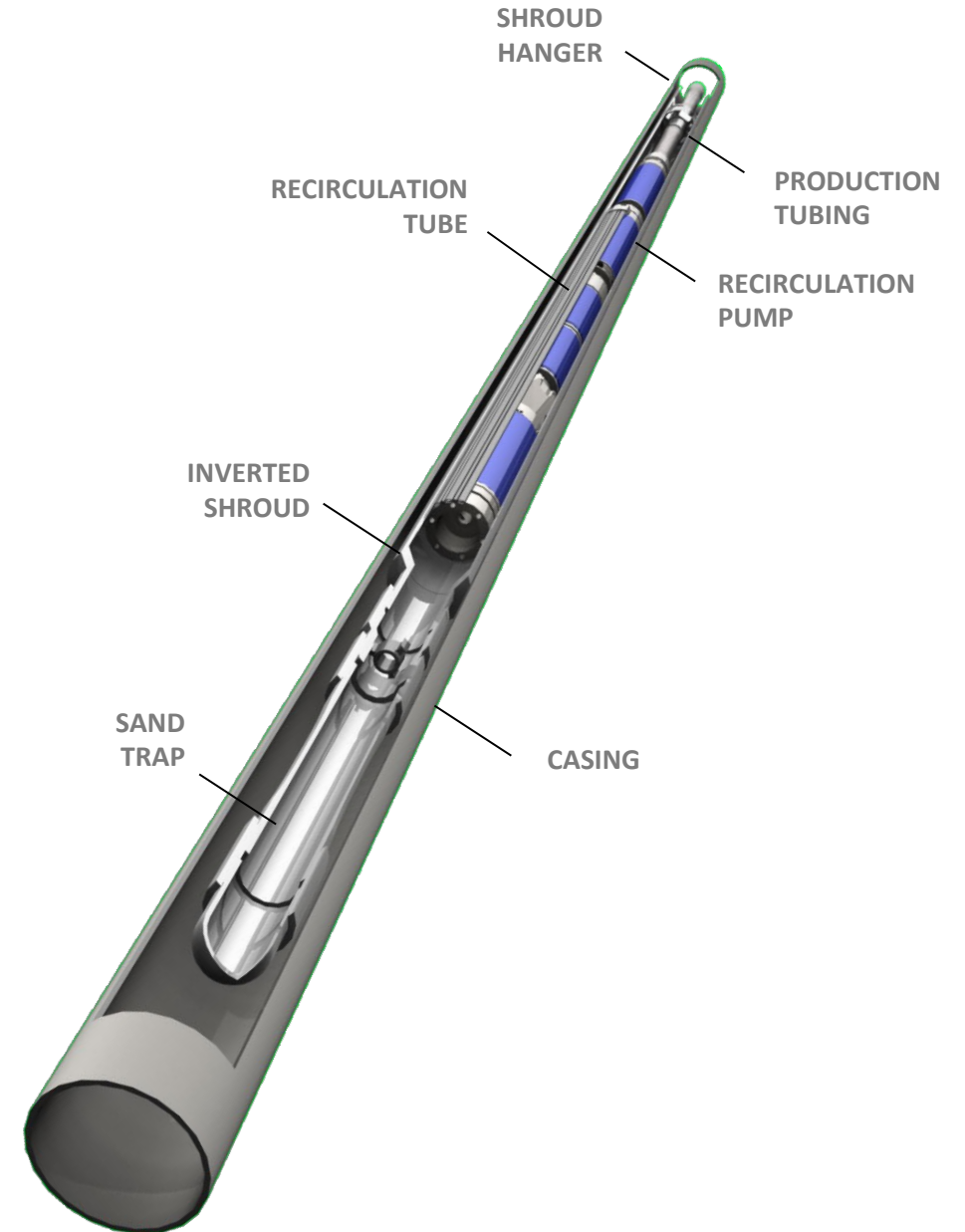
Improve production

- Stabilize production
- Reduce down time
- Improve fluid drawdown for greater reserve recovery

Reduce OPEX

- Increase ESP system reliability
- Ensure adequate motor cooling
- Protect motor lead extension

IMPROVED	INCREASED	INCREASED
ESP	OIL	GAS
RUN LIFE	PRODUCTION	PRODUCTION
73%	19%	43%



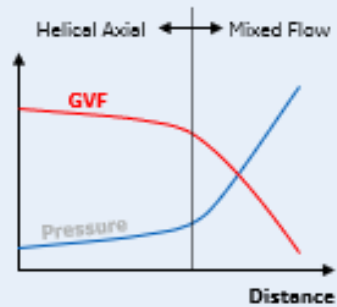


Gas Interference Mitigation

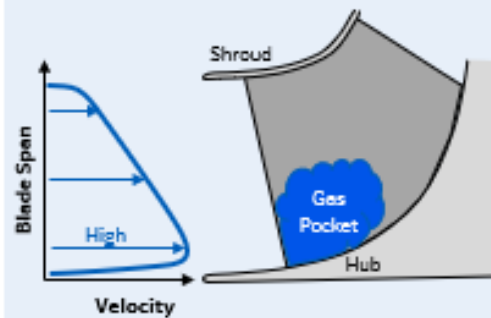
Gas Handling Pumps

- Provides phase mixing
- high exit flow velocity
- Avoid gas locking
- Free gas up to 75%

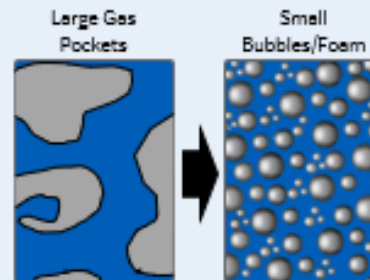
COMPRESSIBILITY



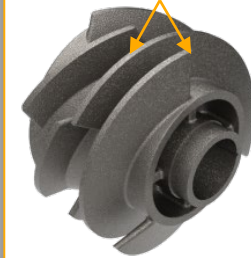
VELOCITY PROFILE



PHASE MIXING

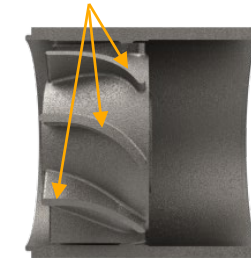


Inlet Vanes



Impeller

Vanes



Diffuser

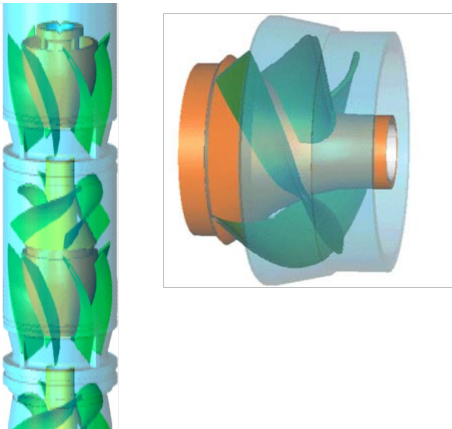




Gas Handling Pumps

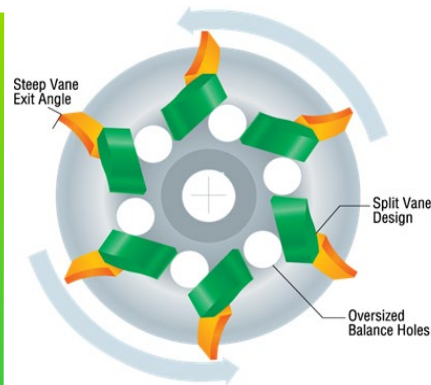
- Advanced computational fluid dynamics (CFD) software
- Optimized stage geometry
- Avoid gas building up in lower pressure areas (Gas lock)

Low NPSH Booster



- ✓ Low Intake Pressure 50psi, GVF > 60%
- ✓ Wide Operating Range
- ✓ High Temperature (SAGD) Applications
- ✓ 300, 400 & 500 series

(Multi-Vane Pump)



- ✓ GVF > 75%
- ✓ Abrasives handling
- ✓ High Efficiency
- ✓ 400 Series Extended Range (MVPER™)
- ✓ Available in 300 to 1025 Series



Helico-Axial Pumps



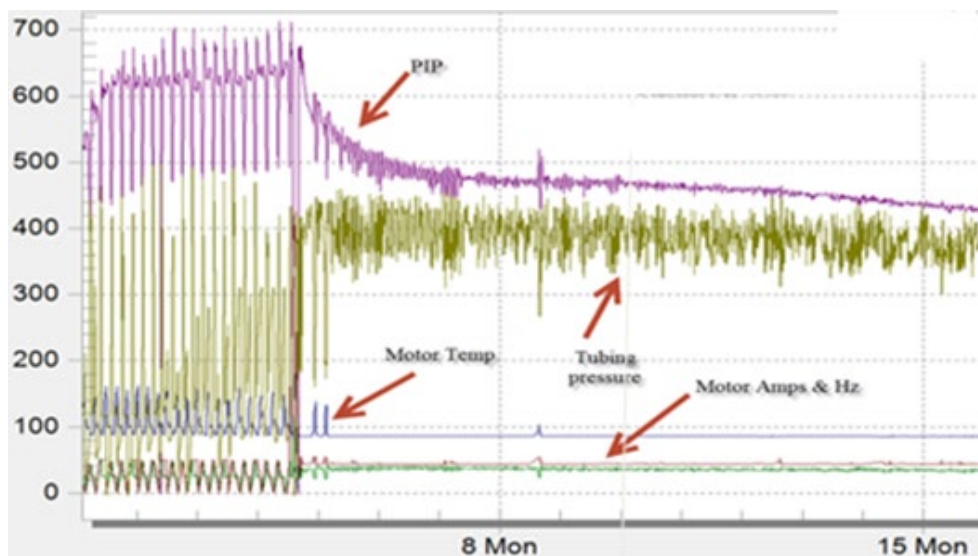
- ✓ High Efficiency
- ✓ GVF > 75%
- ✓ Abrasives handling
- ✓ High Temperature (SAGD) Applications
- ✓ 400 & 500 Series Only
- ✓ Compression Style Construction

Gas mitigation software

- Improve production and reliability
- Mitigate gas locking and pump off conditions
- Manage fluid and pressure drawdown
- Remote Monitoring & Control

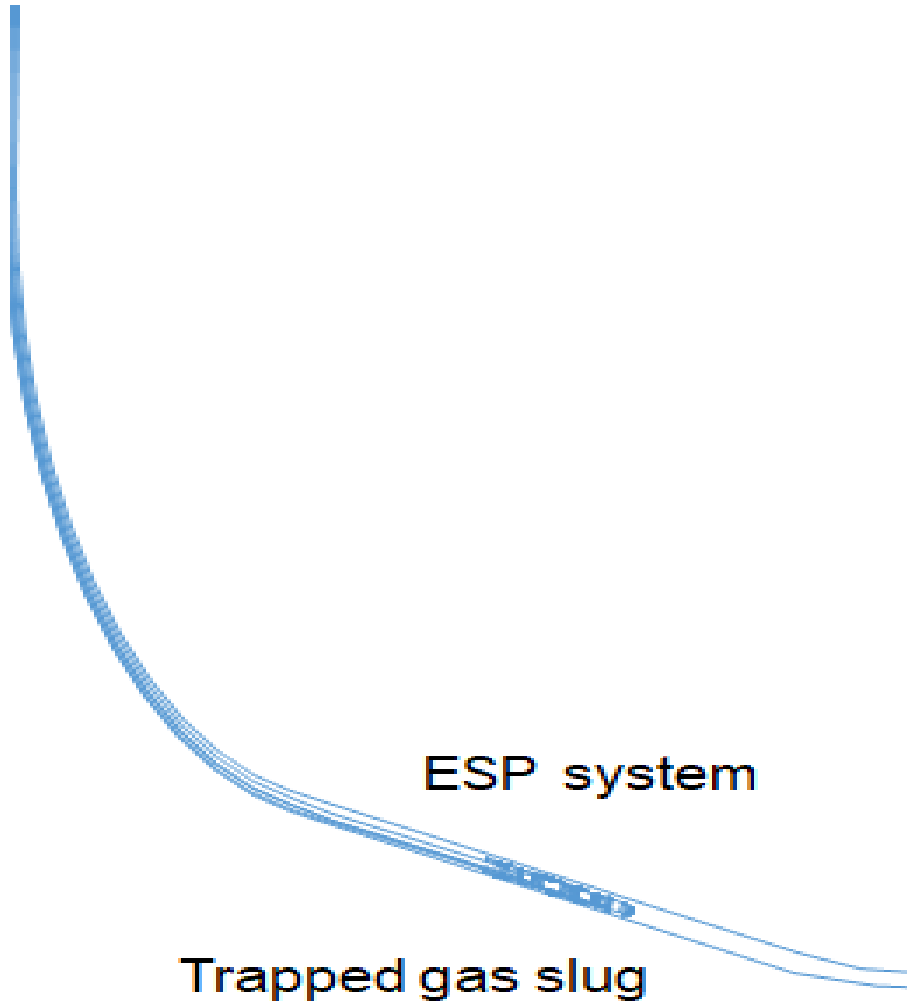


Zenith E-Series Gauge
w/ Motor Diagnostics (MDG)





Tight Radius - Case Study



Permian unconventional oil well

The Challenge

- Well profile included a dogleg of 12° per 100 ft
- Other ESP systems failed due to damage

The Solution

- System landed 445 ft deeper than previous ESP
- Extended range pump to avoid future workover

Results

- 80% increase in production
- Surpassed previous run lives and still running
- Reduced OPEX and minimized production loss



Rapid Decline - Case Study

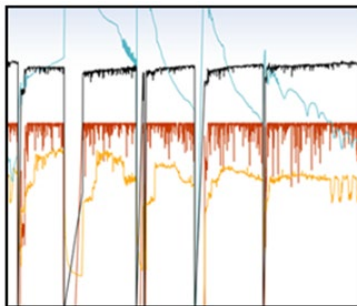


Bakken unconventional oil well

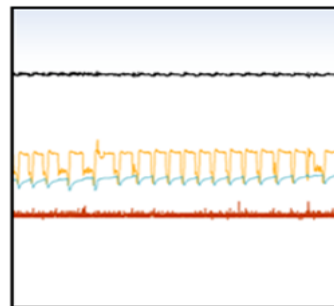
- GLR > 1,500 scf/bbl
- Frequent daily UL shutdowns high GLR (slugs)
- Limited well drawdown - excessive free gas
- Reduced & cyclical daily production

ESP Solution

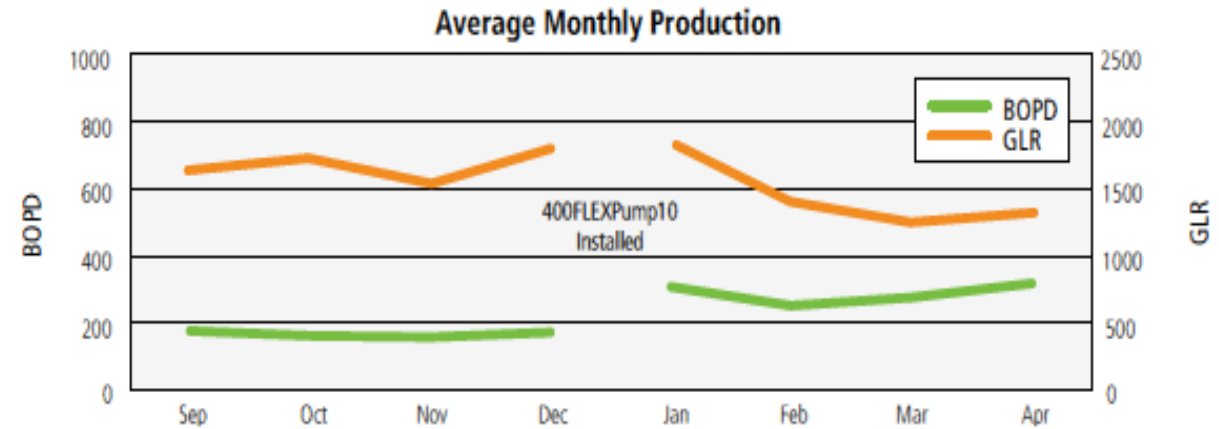
- Installed **Multi-Vane Gas Handling pump + Flex10**
- Broad production rates from 275 to 1,625 BFPD
- VSD software kept the system operational 24/7



Before



After



Results

- Operation improvement – Stabilized
- Extended range pump increased oil production by 42%
- Cash flow improvement with increased oil production
- Reduced NPT (downtime)
- VSD software proved effective for the dynamic Bakken well environment



Integrated Solutions for main Unconventional Resources Challenges

INCREASED PRODUCTION

- Above 19%
- Reserve recovery

DEEPER DEPTHS

- Doglegs up to 25°/100 Ft

HIGHER RUN LIFE

- Improved reliability
- Lower interventions

Conclusions

- Improved well operating conditions for high gas and slugs
- Deeper setting depths with doglegs up to 25°/100 Ft
- Increased total oil production
- Increased equipment run life – Improved reliability
- Significant improvement of well cash flows
- Reduced NPT (downtime)
- Reduced operating expenses (OPEX)
- Effective and fast return on investment (ROI)

STABILIZED CONDITIONS FOR HIGH GOR / SLUGS

OPERATING CASH FLOW IMPROVEMENT

OPEX REDUCTION & FAST RETURN ON INVESTMENT (ROI)

Lessons Learned

Well Construction & Facilities

- Larger Casing size - 5 ½"
- Tangent ~ 70° (100-150 Ft)
- Independent csg. & tbg. gas separation
- Surface instrumentation

Artificial Lift Systems

- Size to match well decline (One pump)
- Downhole sensors for all ALS
- Remote monitoring and control
- Solids - protection (front end – back end)
- Downhole chemical treatment (Scale)

The Future

- Artificial Intelligence (AI) to optimize operation
- Machine Learning / Digital twins for reliability
- Higher efficiency, PMM & HS



Questions ?