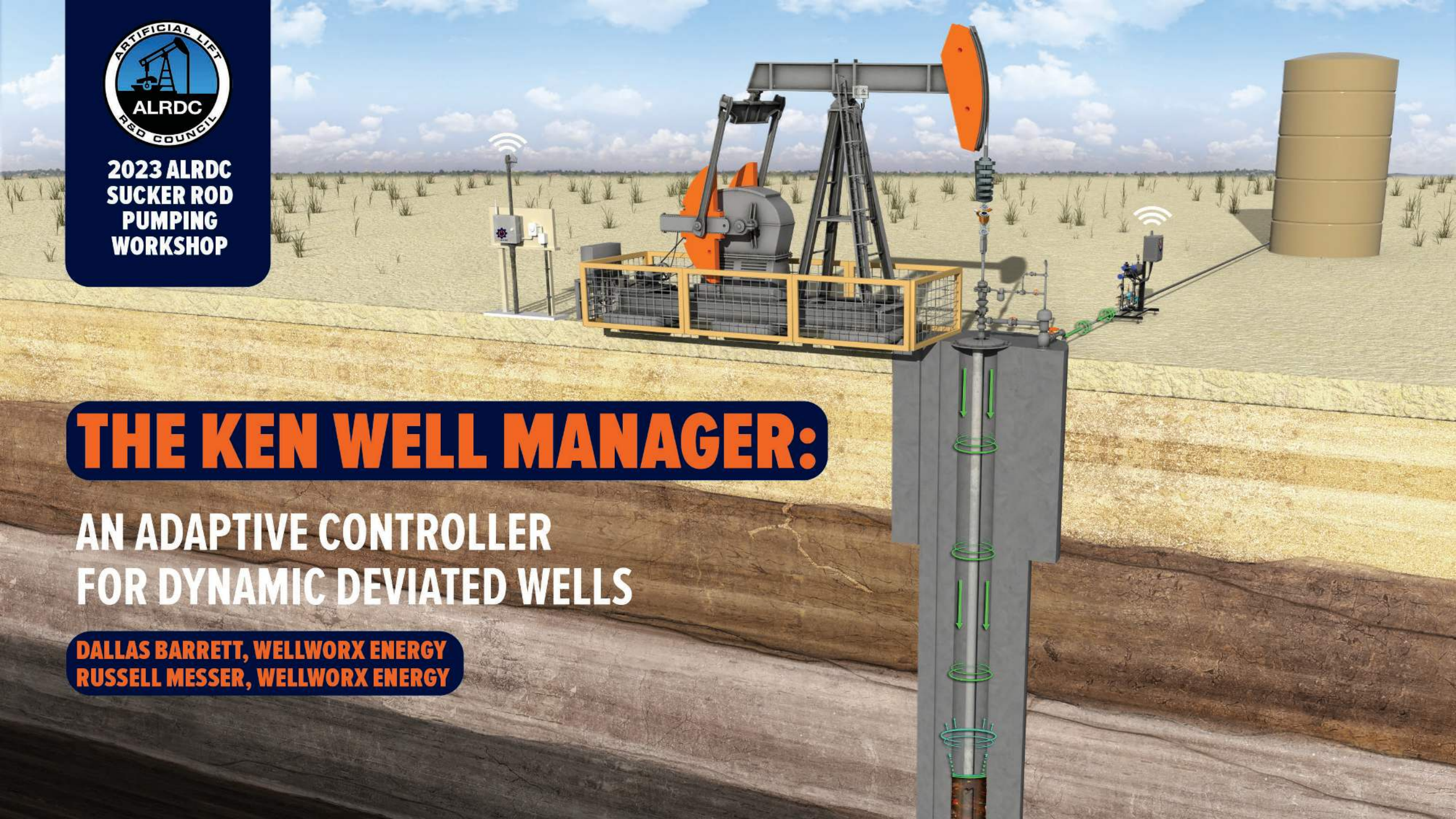
2023 ALRDC SUCKER ROD PUMPING WORKSHOP

THE KEN WELL MANAGER:

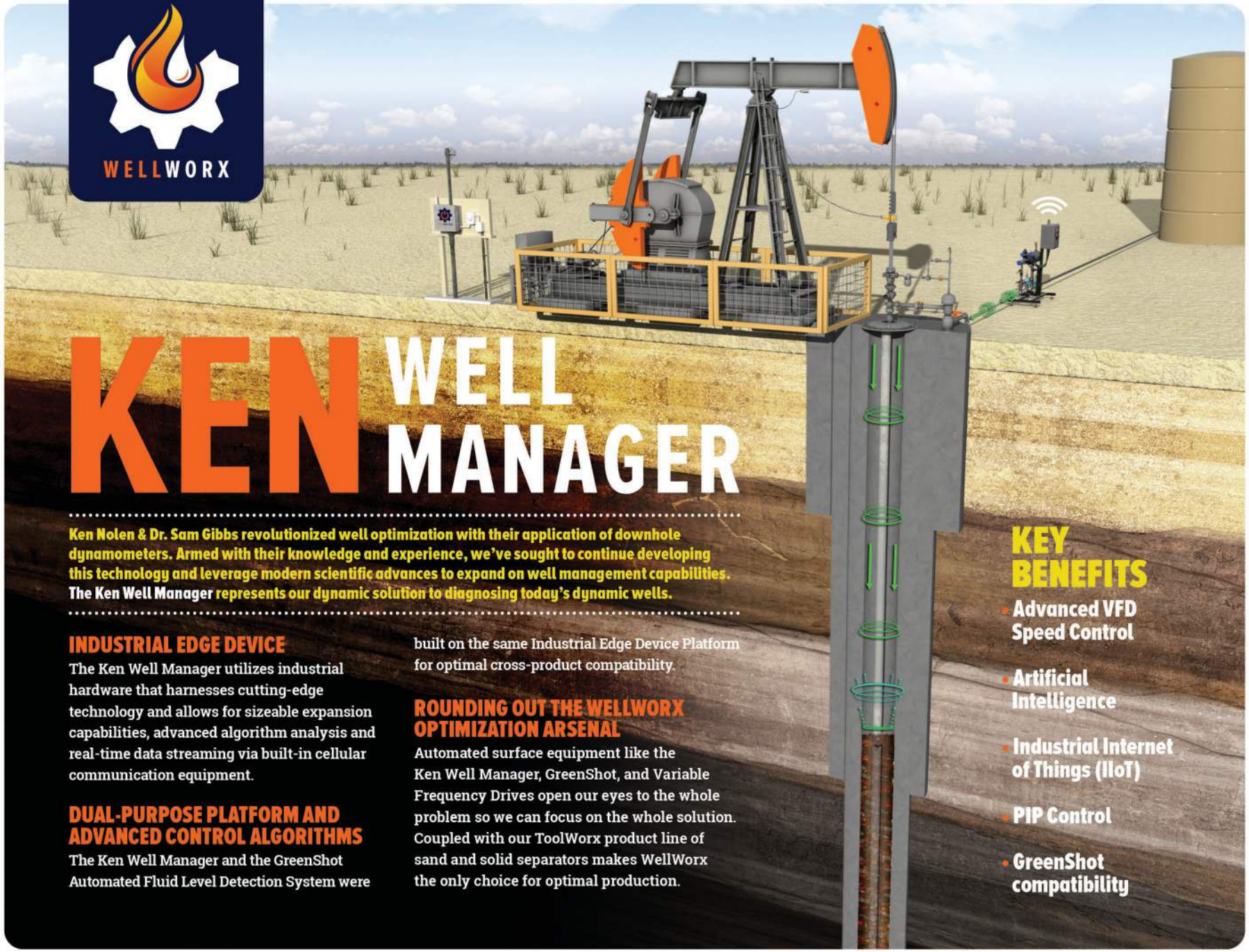
AN ADAPTIVE CONTROLLER FOR DYNAMIC DEVIATED WELLS

DALLAS BARRETT, WELLWORX ENERGY
RUSSELL MESSER, WELLWORX ENERGY



KEN WELL MANAGER

WELLWORX



KEN WELL MANAGER

Ken Nolen & Dr. Sam Gibbs revolutionized well optimization with their application of downhole dynamometers. Armed with their knowledge and experience, we've sought to continue developing this technology and leverage modern scientific advances to expand on well management capabilities. The Ken Well Manager represents our dynamic solution to diagnosing today's dynamic wells.

INDUSTRIAL EDGE DEVICE

The Ken Well Manager utilizes industrial hardware that harnesses cutting-edge technology and allows for sizeable expansion capabilities, advanced algorithm analysis and real-time data streaming via built-in cellular communication equipment.

DUAL-PURPOSE PLATFORM AND ADVANCED CONTROL ALGORITHMS

The Ken Well Manager and the GreenShot Automated Fluid Level Detection System were built on the same Industrial Edge Device Platform for optimal cross-product compatibility.

ROUNDING OUT THE WELLWORX OPTIMIZATION ARSENAL

Automated surface equipment like the Ken Well Manager, GreenShot, and Variable Frequency Drives open our eyes to the whole problem so we can focus on the whole solution. Coupled with our ToolWorx product line of sand and solid separators makes WellWorx the only choice for optimal production.

KEY BENEFITS

- Advanced VFD Speed Control
- Artificial Intelligence
- Industrial Internet of Things (IIoT)
- PIP Control
- GreenShot compatibility

KEN WELL MANAGER

WHAT SETS OUR CONTROLLER APART?

- Pump Intake Pressure (PIP) Control Mode
- Dynamic Pump Leakage Algorithm
- Integrated Variable Frequency Drive (VFD) Packages
- Intrastroke Speed Changes with VFD Speed Zones
- Optional High Resolution Touch Screen
- Modular design supports up to three communications sleds and up to ten I/O modules
- Real-time data, event and security logging to microSD cord or via FTP
- Industrial construction for reliable operation
- Wide operating temperature range

IIOT EDGE DEVICE: THE POWER OF THE FUTURE. MORE THAN JUST A BOARD!

TOTAL WELL CONTROL
- Improved Production Calculation
- Dynamic Control Algorithms
- Integrated Liberty Lift XL Speed Control

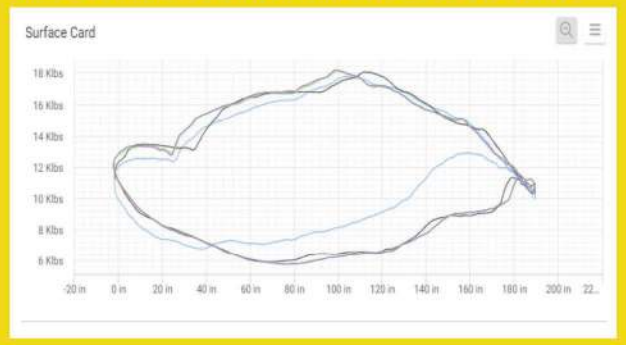
COST EFFECTIVE, EXPANDABLE IO PLATFORM
- (6) Analog Inputs
  - (2) High Speed for Load and Position
- (2) Analog Outputs
- (8) Digital Inputs
- (8) Digital Outputs
- Easily expanded for even more capabilities!

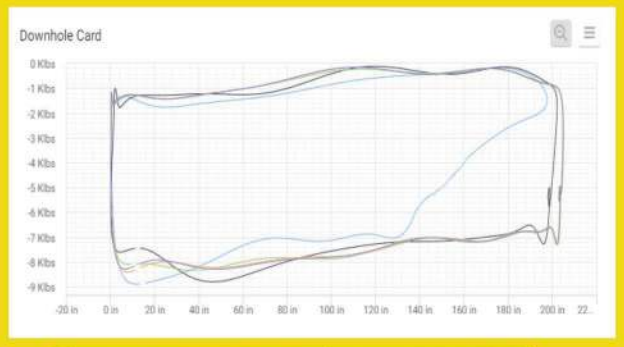
SIMPLE TO USE, CLOUD-BASED USER INTERFACE
- We've done the heavy lifting so you don't have to!
- No SCADA system? No Problem!
- Real-time cards
- Your data - anytime, anywhere

CELLULAR AND WIFI COMMUNICATIONS BUILT-IN!
- No ancillary radios or equipment necessary
- Out-of-the Box Usability
- Three months of free well monitoring included

BEST-IN-CLASS END DEVICES
- The industry's most accurate end devices
- Simple, safe, precise install
- Maintenance free with the best warranty in the industry
- No more misplaced crank sensors and bad position data

DYNAMIC WELLS REQUIRE DYNAMIC SOLUTIONS.





WELLWORX

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Questions? Please contact our Automation team at **432.618.0199**
OR **info@wellworxenergy.com**

INCLINOMETER VS CRANK AND MOTOR HALL EFFECT SWITCHES TO MEASURE POLISHED ROD POSITION

BY KEN NOLEN

Although accurate polished rod positions can be measured with a Hall Effect Switch System (HESS) there are many problems involved in maintaining accuracy and safety when compared to an Inclinometer System (IS). Following is a list of problems associated with HESS.

1 A very common problem with the HESS is misalignment of the crank magnet and its Hall Effect Switch to accurately sense bottom (or top) dead center of the polished rod. Magnet and/or switch can be inadvertently moved out of alignment when servicing the unit (balancing, greasing, painting etc.). Also, if unit rotation is changed the alignment must be adjusted. This is necessary because the switch is activated by the leading edge of the magnet and not the center of the magnet. Misalignment results in a phase shift between polished rod position and polished rod load which distorts the calculated pump card. For example, misalignment can cause the pump cards to lean to the right and falsely indicate that the tubing anchor is not holding. The above problems do not exist with IS.

2 Installation of HESS is more complicated to install and requires Lock Out Tag Out safety procedures. IS reduces safety hazards during installation and maintenance and does not require Lock Out Tag Out safety procedures. The inclinometer is equipped with a magnet and is conveniently mounted out of harm's way on the bottom of the beam and near the front of the saddle bearing housing. To prevent using a bucket truck or climbing the pumping unit ladder the inclinometer is installed and retrieved with a utility pole. The data cable from the inclinometer to the POC is attached to the structure of the pumping unit with magnets 5-6-feet apart on the cable.

3 The motor HESS is subject to damage from belt failures and from rodents and snakes. This problem does not exist with IS.

4 The HESS requires unit geometry (6 dimensions) from a pumping unit database. If the unit is not in the database a similar unit is normally selected which can reduce the accuracy of the POC. IS eliminates the need for a pumping unit database. The only measurement required is the stroke length of the pumping unit.

5 To summarize the IS position measurements are accurate and the system is less complicated, easier to install, requires less maintenance and reduces safety hazards.

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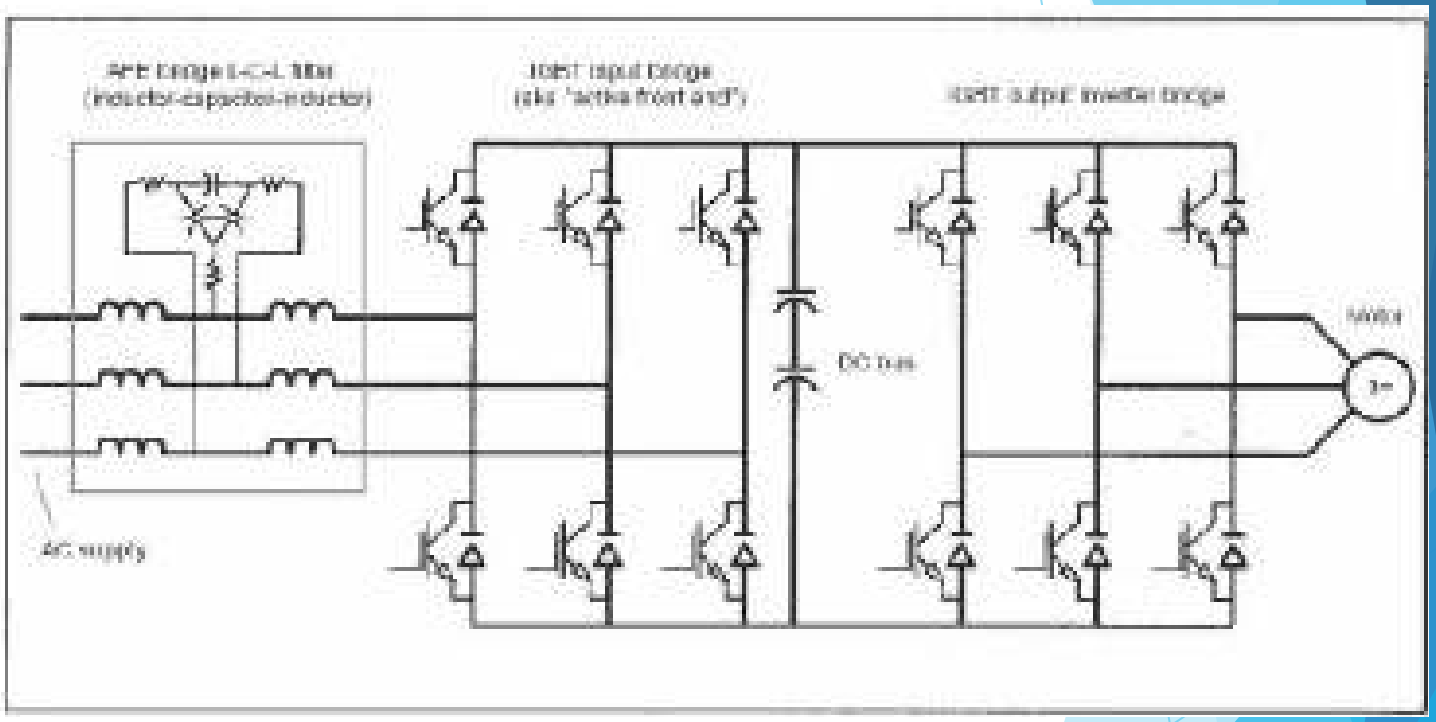
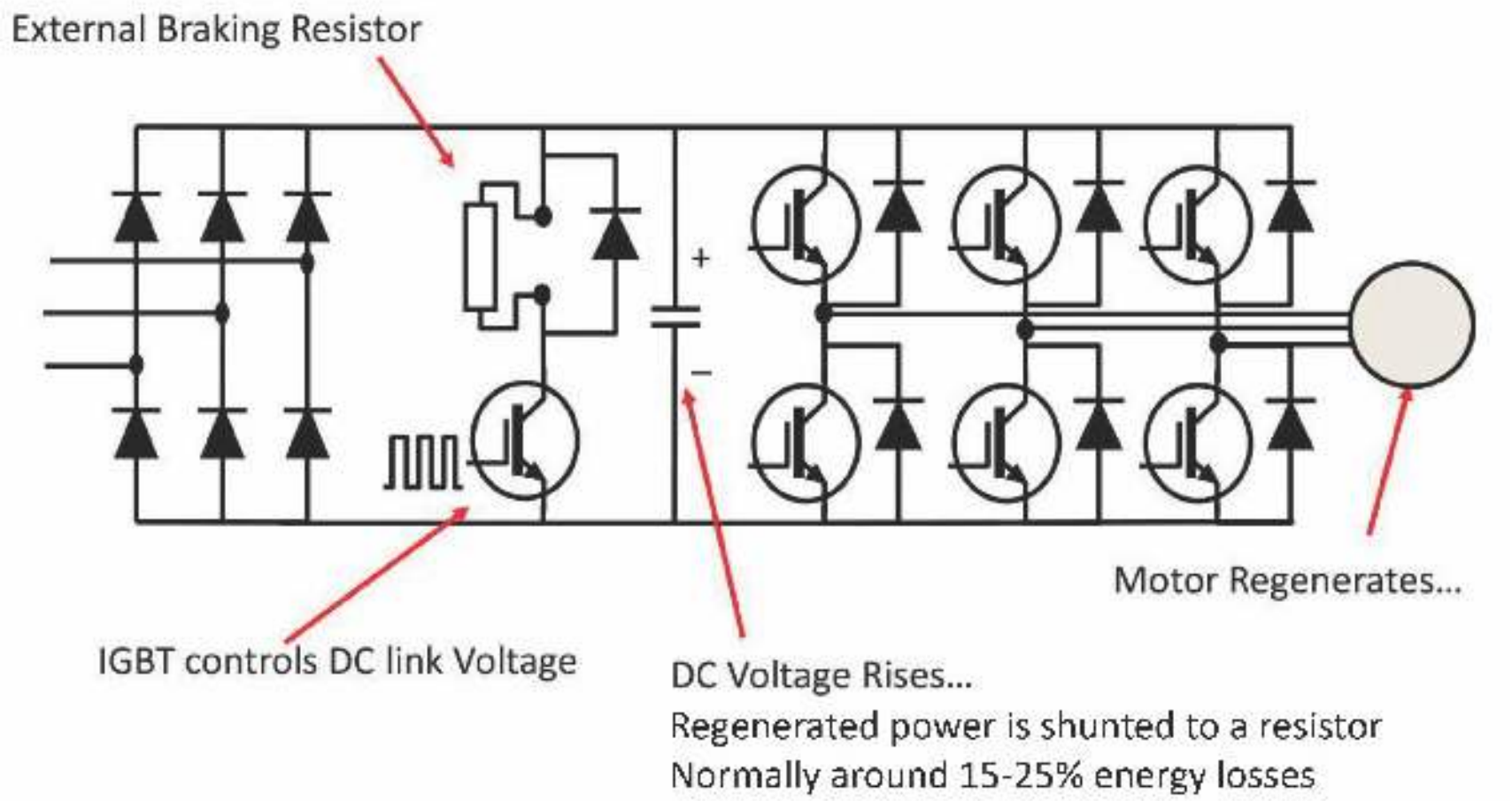
<< The WellWorx Inclinometer

ACTIVE FRONT END VFD

- **WHAT IS IT?**
  - Motor Controller
  - Motor Output identical to “normal” VFD
  - Bidirectional Rectifier (power in or out)
  - Inherently low harmonics (IEEE519)
  - 100% Braking Power / 100% Duty Cycle



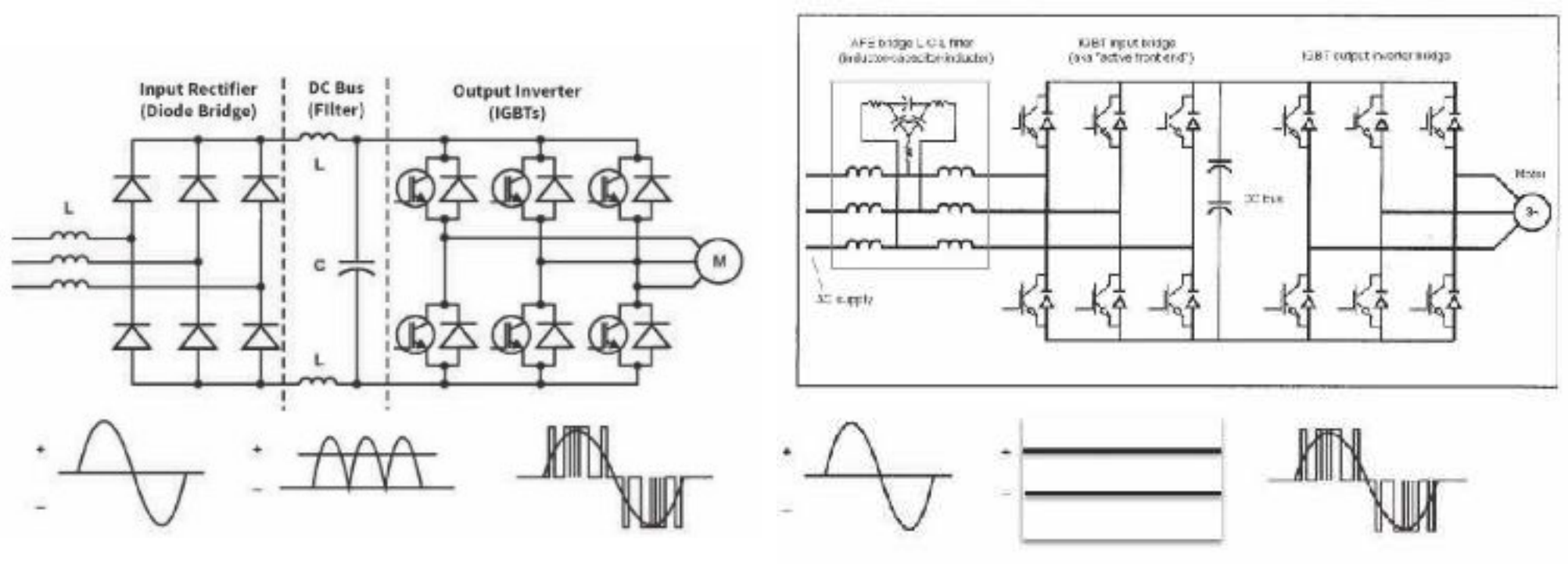
SIX PULSE VFD



ECONOMICS AND ESG SAVINGS

- 150HP= 112KW
- 8760 hours per year
- Annual consumption at 100%
- load/cycle is 8760x112 = 981,000 kwH
- At 7 cents per kwH, this is $68,670/year
- 20% savings is >$13k per year
- 85 tons of CO2 emission reduction, helping ESG objectives

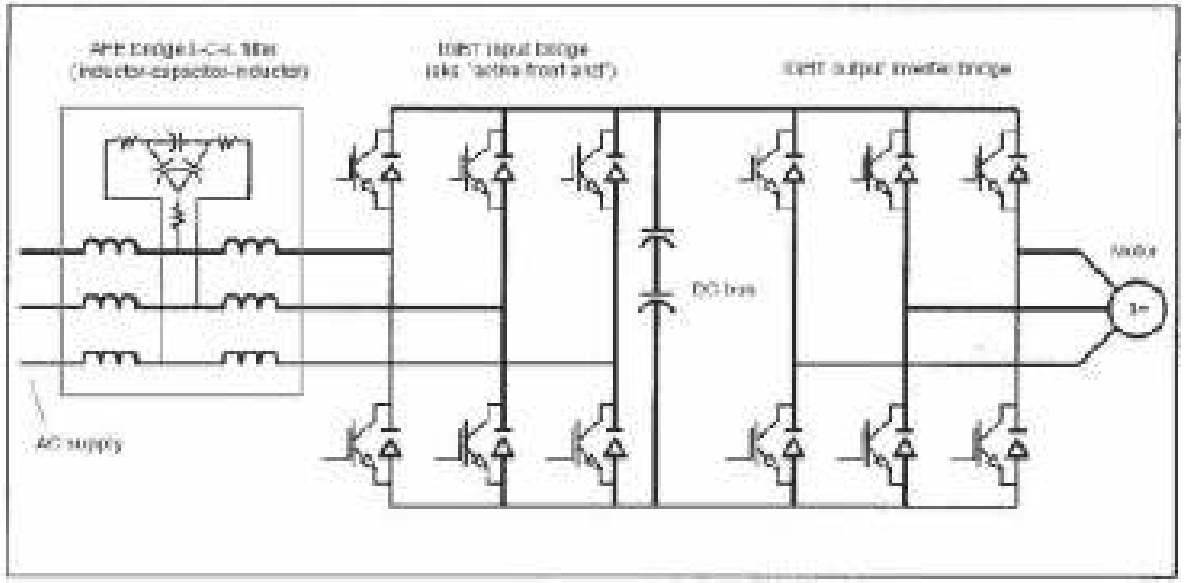
MOTOR PERFORMANCE COMPARISON



DIFFERENCE: Excess power flows back to the grid, eliminating braking thermal losses

ACTIVE FRONT END VFD

- **BENEFITS**
  - Low Harmonics
  - 100% Braking Torque
  - No Brake Resistors of Harmonic Filters



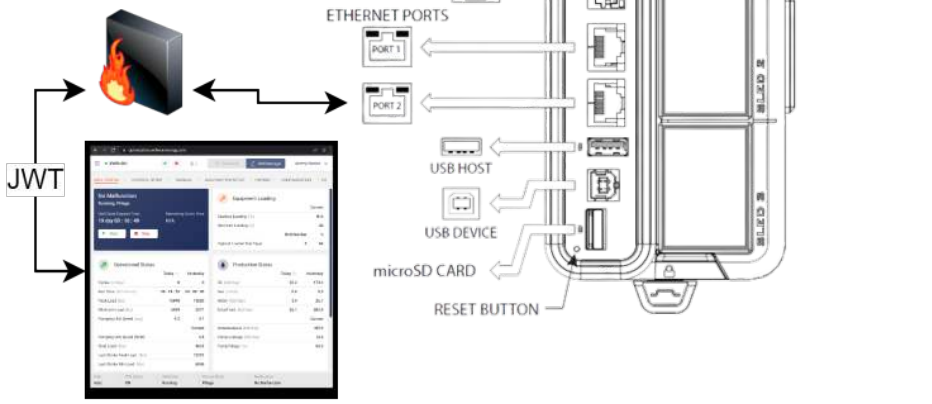
Artificial Lift R&D Council

BASE NETWORK TOPOLOGY

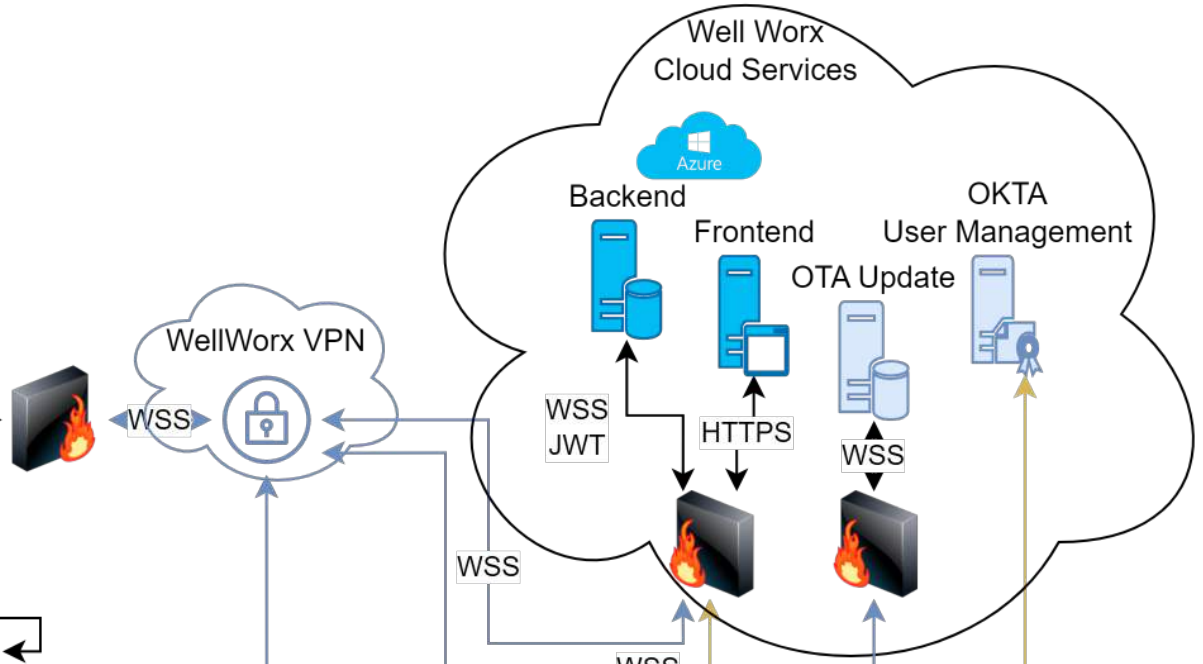
- **KWM WEB APPLICATION + BACKEND/FRONTEND SERVER**
  - User groups created by the client. Operators can see all wells in their group.
  - Configure and monitor wells (i.e. Start/Stop, reset alarms, etc.).
  - Historian – Cards (i.e. Startup, Shutdown, Hourly, etc.). Fillage, PIP, SPM, etc recorded for every stroke.
  - Live sensor data.
  - Additional algorithms (predictive cards, etc.).
- **LOCAL HMI**
  - Local version of the KWM Web Application (limited features).
- **OTA UPDATE SERVER**
  - Automatic FW updates for KWM, RL, and HMI.
- **RED LION WEB INTERFACE**
  - Configure network settings, COM's, etc.

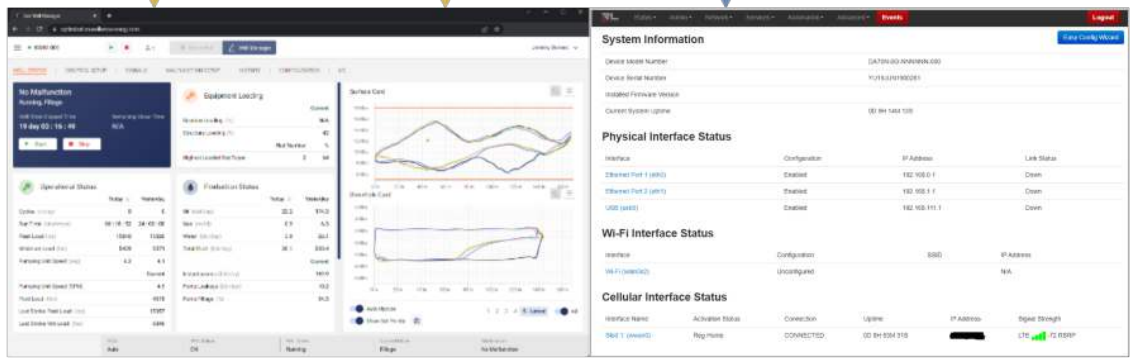
BASE NETWORK TOPOLOGY (cont.)

- **OKTA USER MANAGEMENT SERVER**
  - User Authentication.
- **LOCAL NETWORK FIREWALL**
  - Restrict IP's and ports through RL firewall settings.



Local HMI



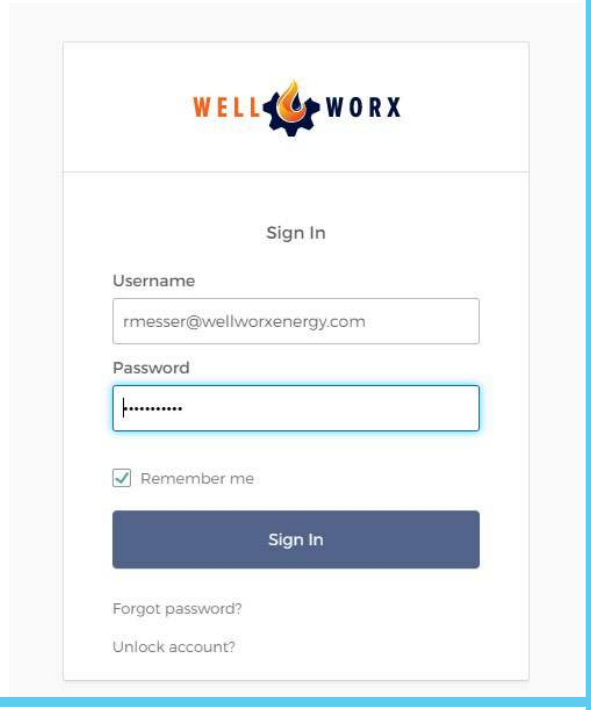


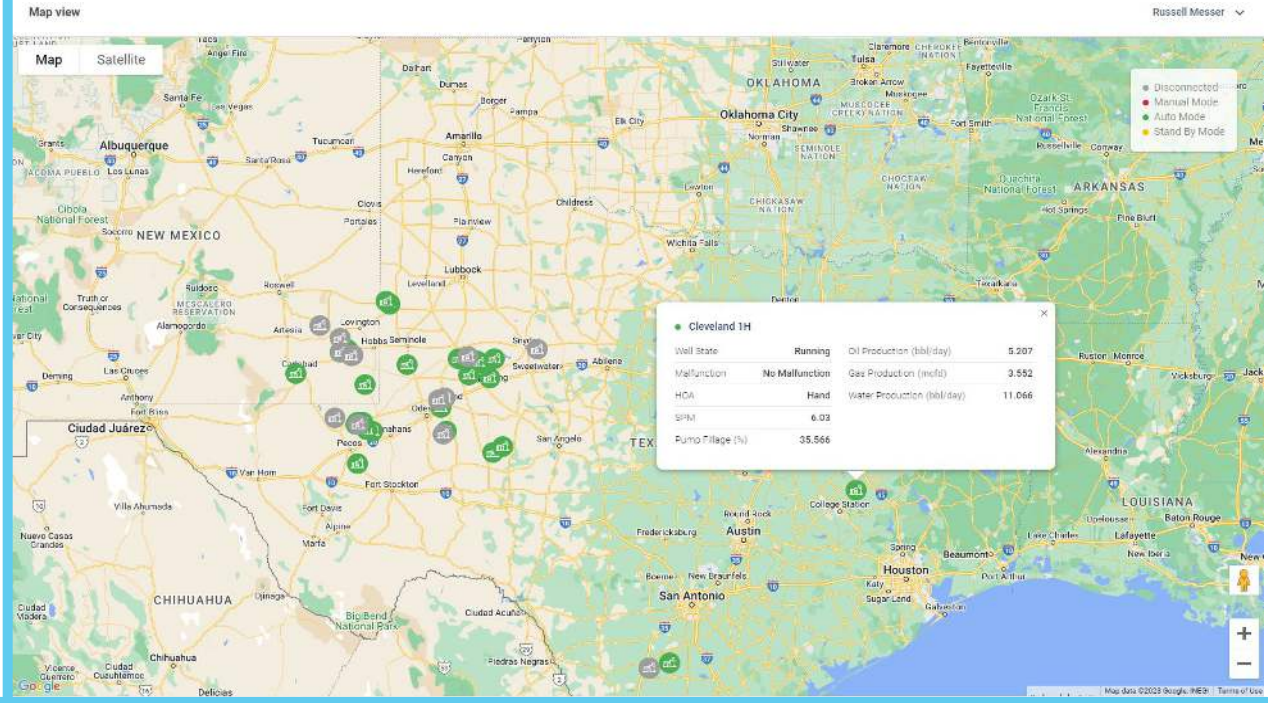
KWM Web Application

Red Lion Web Interface

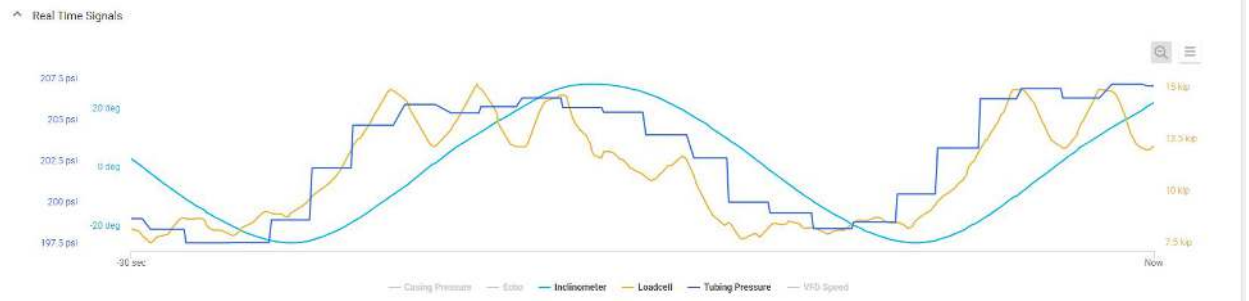
GO LIVE!

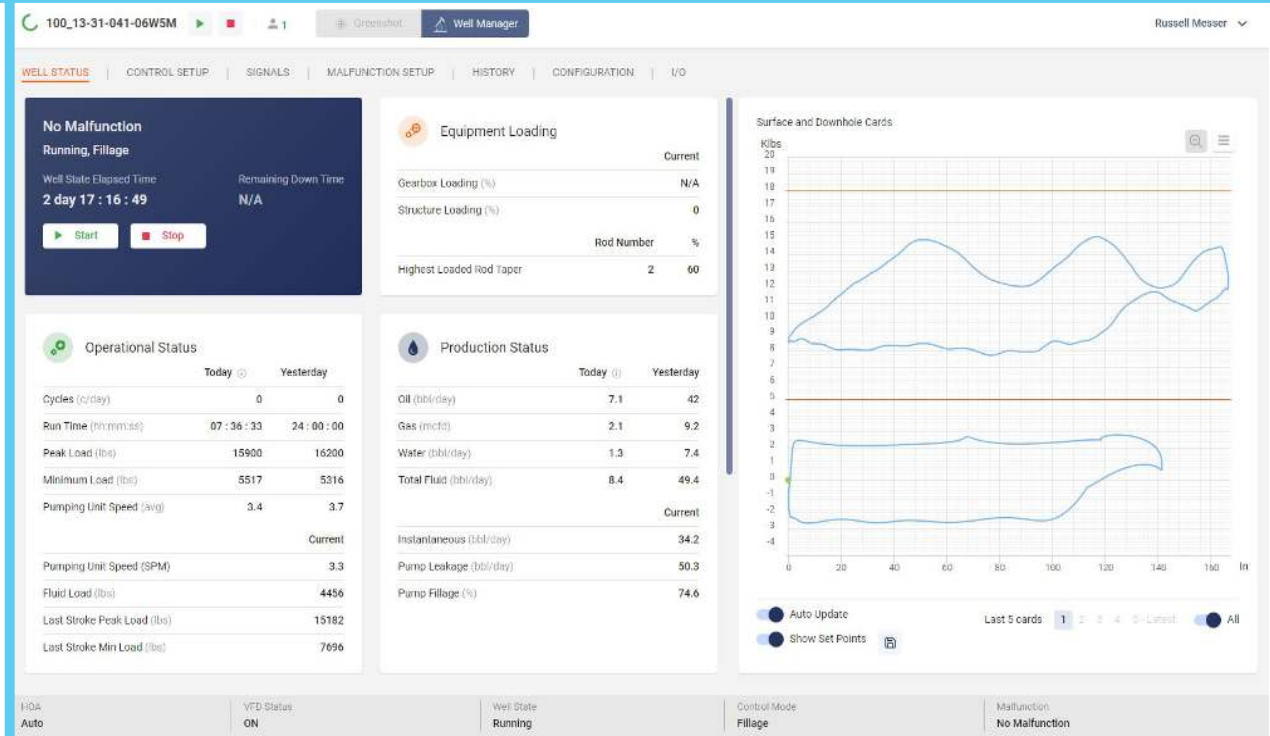
- http://104.211.19.125:8383/details/rpCP2XoMSPqgNOKHzo4Ddw/pocWellStatus





Well State	Malfunction	HOA	SPM	Pump Fillage	Production Oil	Production Gas	Production Water
Select status	Select malfunction	Select HOA					
Stopped	No Malfunction	Off	9.99	0.065	-7.717	0.267	-16.397
Unable To Stop	No Malfunction	Auto	6.44	8.554	-4.956	8.097	-10.533
Stopped	No Malfunction	Off	7.04	12.545	0.385	3.914	0.818
Running	No Malfunction	Auto	3.95	13.704	-10.231	150.403	-92.077
Unable To Start	No Malfunction	Auto	5.79	13.779	4.044	0.299	8.595
Running	No Malfunction	Hand	6.05	30.959	3.825	3.465	8.129
Unable To Start	No Malfunction	Auto	5.36	33.089	0.542	1.154	2.31
Running	No Malfunction	Auto	7.67	59.621	85.72	17.479	128.579
Running	No Malfunction	Auto	5.71	65.013	46.713	10.234	99.264
Running	No Malfunction	Auto	3.12	66.246	49.214	0.125	104.579
Running	No Malfunction	Auto	7.14	67.526	112.205	49.016	238.435
Running	No Malfunction	Auto	8.13	67.616	103.151	21.983	219.197
Running	No Malfunction	Auto	6.9	69.235	115.776	24.856	246.024
Running	No Malfunction	Auto	3.42	71.617	94.3	18.842	200.386
Running	No Malfunction	Auto	4.22	72.548	150.168	27.838	319.106



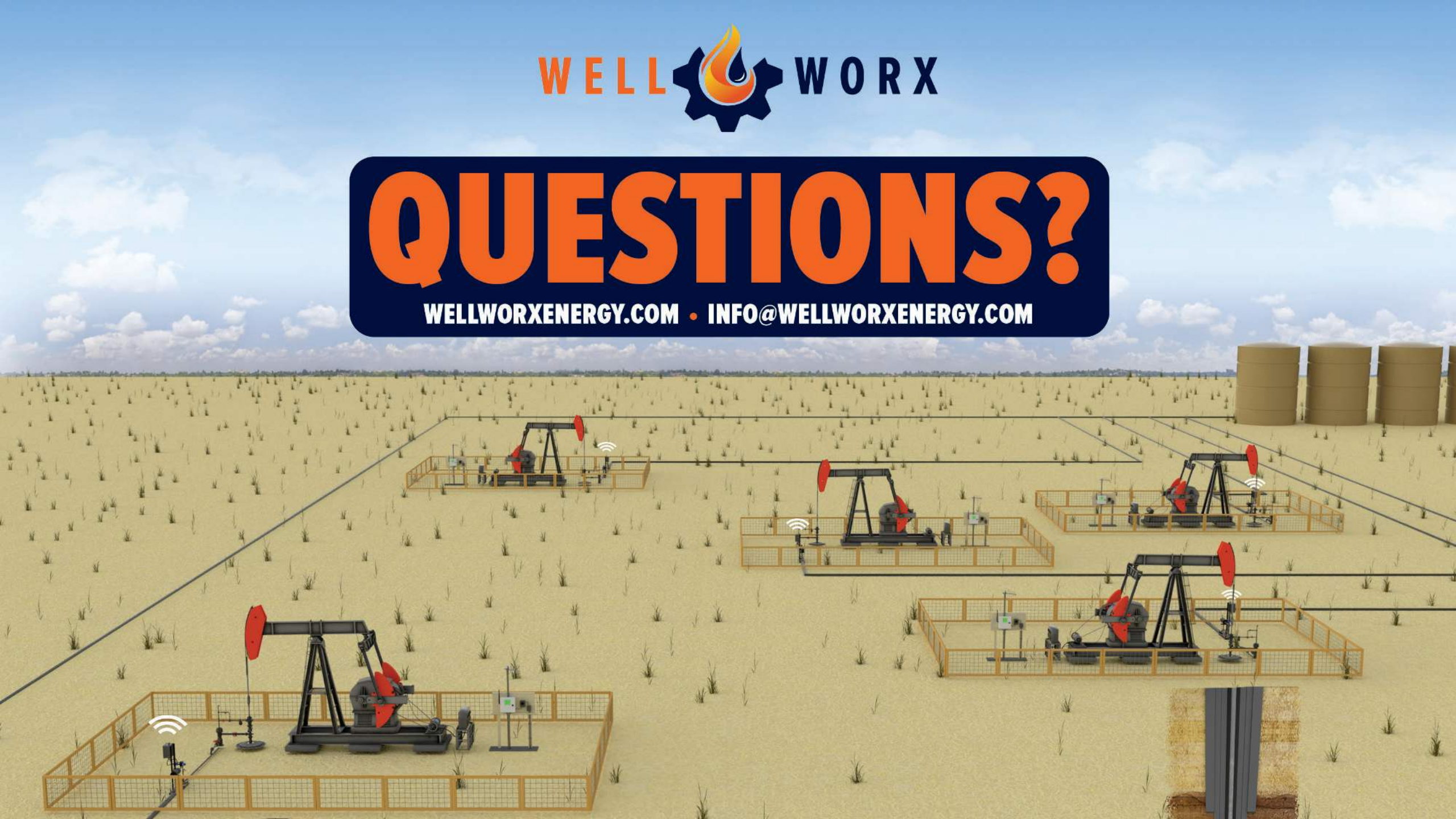


KEY DIFFERENTIATORS

- **CLOUD BASED SYSTEM**
  - Savings opportunities around all thing's comms
  - Unlimited Processing Power
- **REMOTE PUMP ACTION CHECKS**
- **PLUNGER VELOCITY PLOTTED OVER DH CARD FOR ADVANCED OPTIMIZATION**
  - Verifying pump fillage pick
  - Verifying tags or speed changes
  - Optimizing Intra-stroke speed changes w/real time plunger velocity considered
- **20 IN-HOUSE PROGRAMMERS/DEVELOPERS**
  - Road Map to include:
    - Tying in automated fluid level systems
    - Tying in Rod Design Program

KEY DIFFERENTIATORS (cont.)

- STROKE COUNTER IN CONTROLLER
- INDUSTRY LEADING AFE HARMONICS FILTERING WHEN TESTED AGAINST INDUSTRY STANDARD
- AUTOMATIC ADJUSTMENT OF VISCOUS DAMPING FACTOR - AVAILABLE IN KWM Q4 2023
- IMPROVED DHC MECHANICAL FRICTION FLUID LOAD PICK - AVAILABLE IN KWM Q4 2023
- ENHANCED PUMP FILLAGE PICK - AVAILABLE IN KWM Q4 2023
- DOWNHOLE PATTERN MATCHING - Q1 2024
- SOLVING FOR DEVIATED DOWNHOLE CARD - Q1 2024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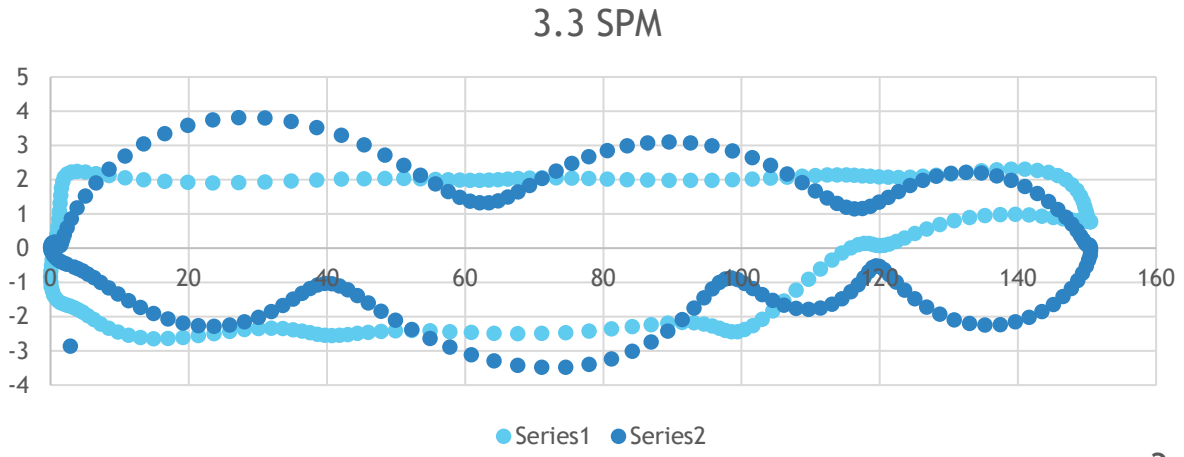
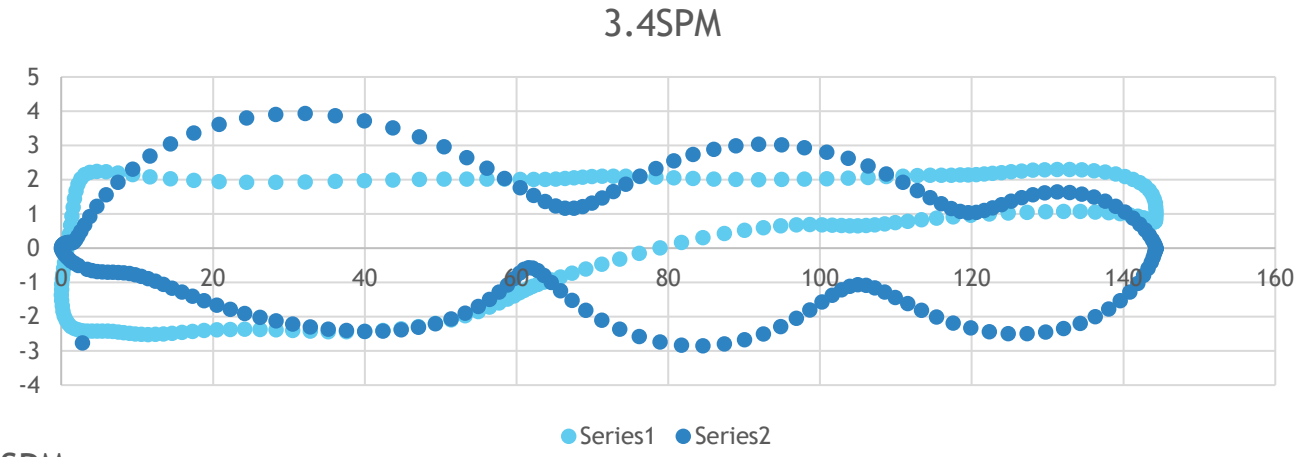
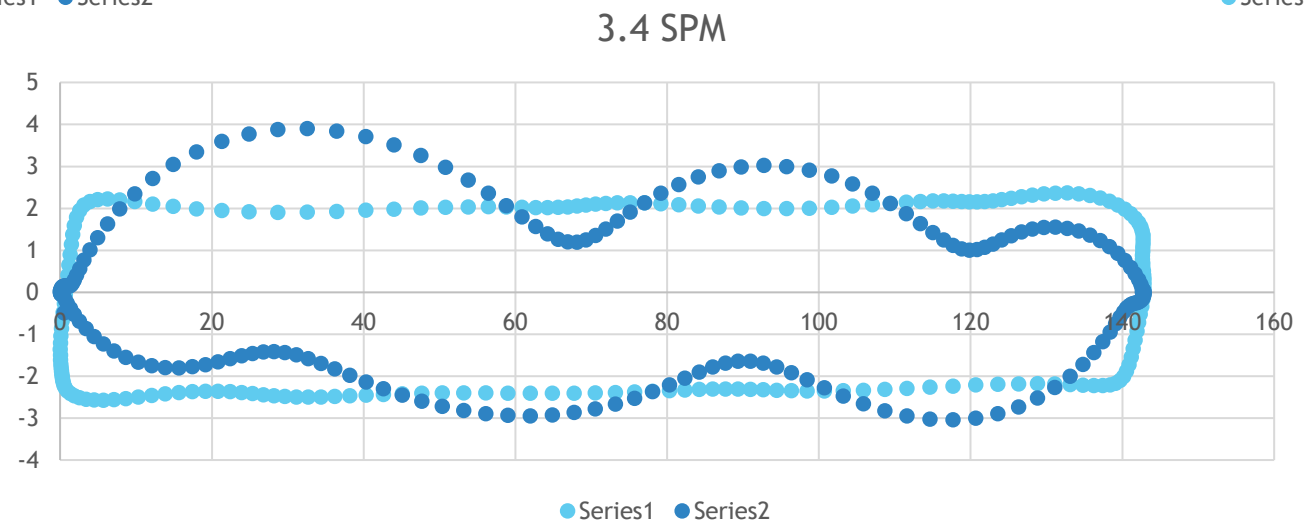
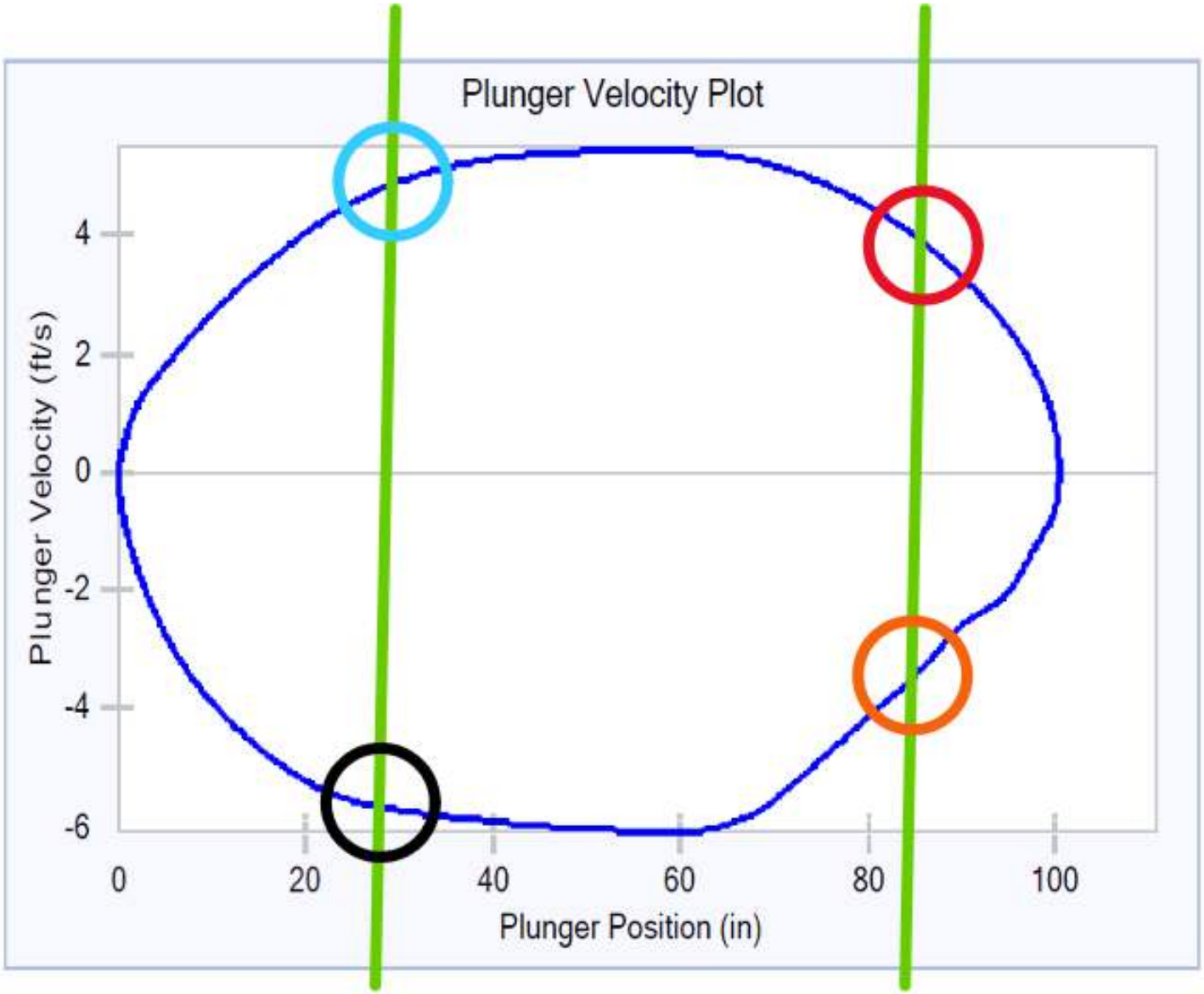
PLUNGER VELOCITY PLOTTED W/ SURFACE AND DH CARDS

- Change in Plunger Velocity captured as gas interference severity changes.
- Same well, conventional running at 3.3SPM.

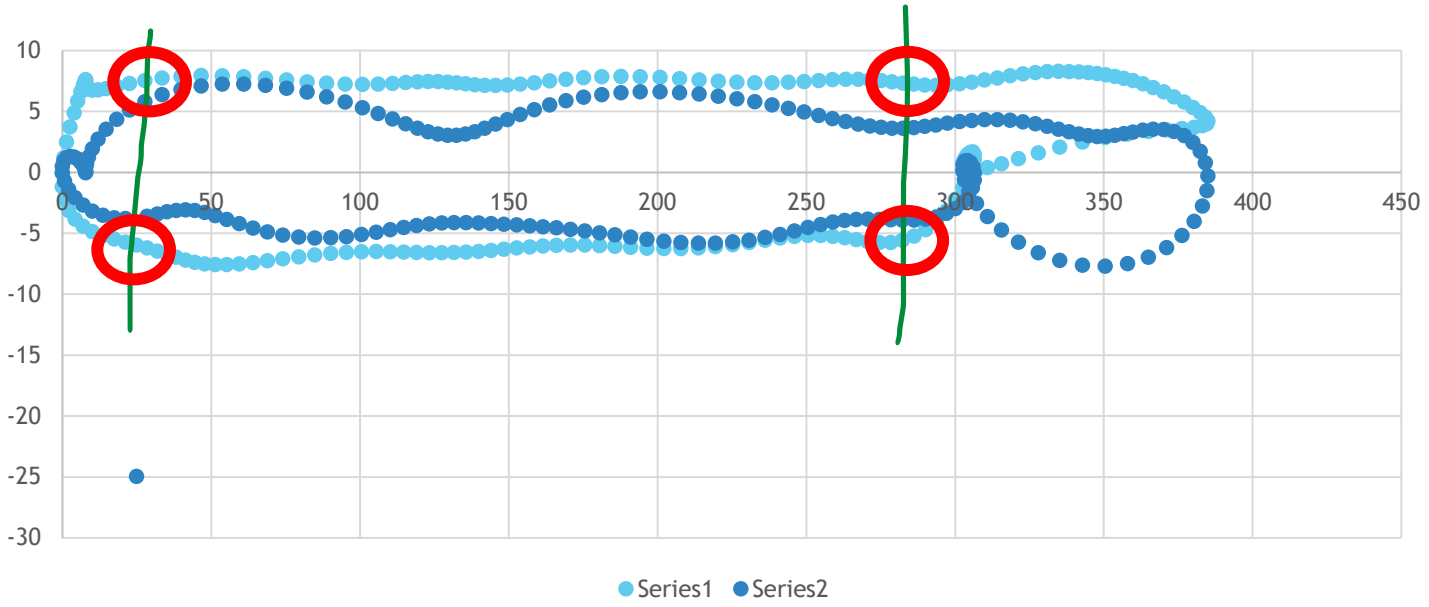


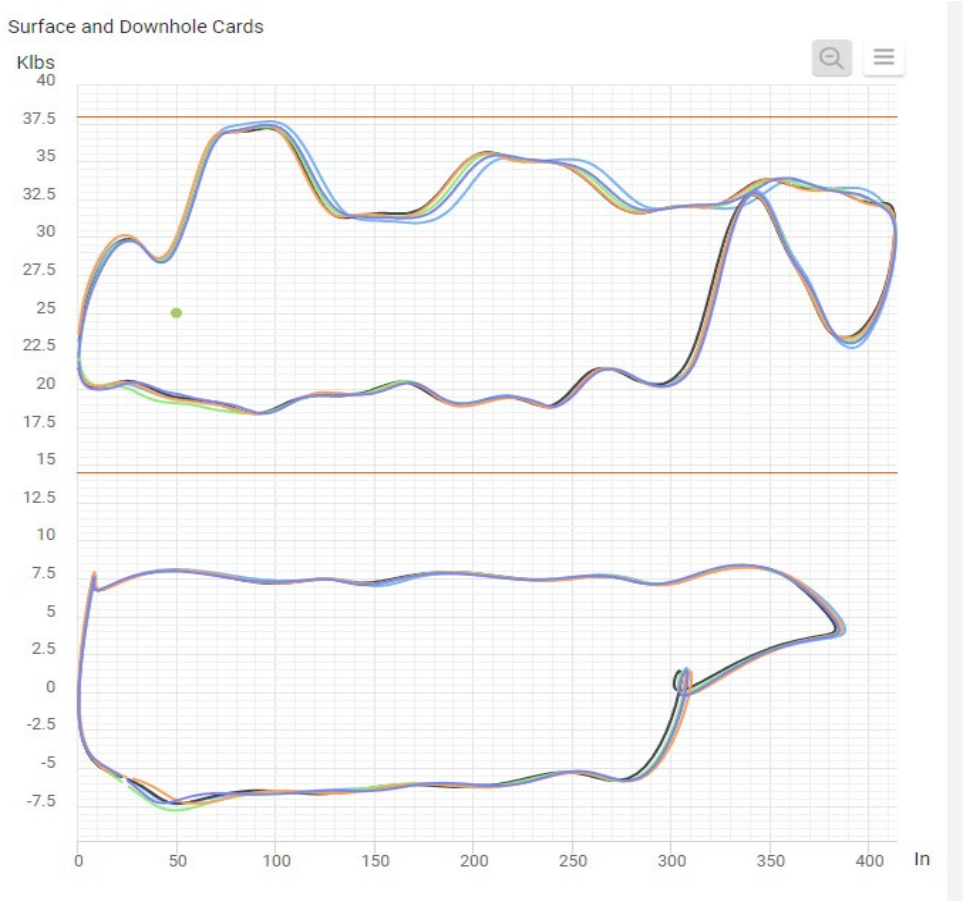




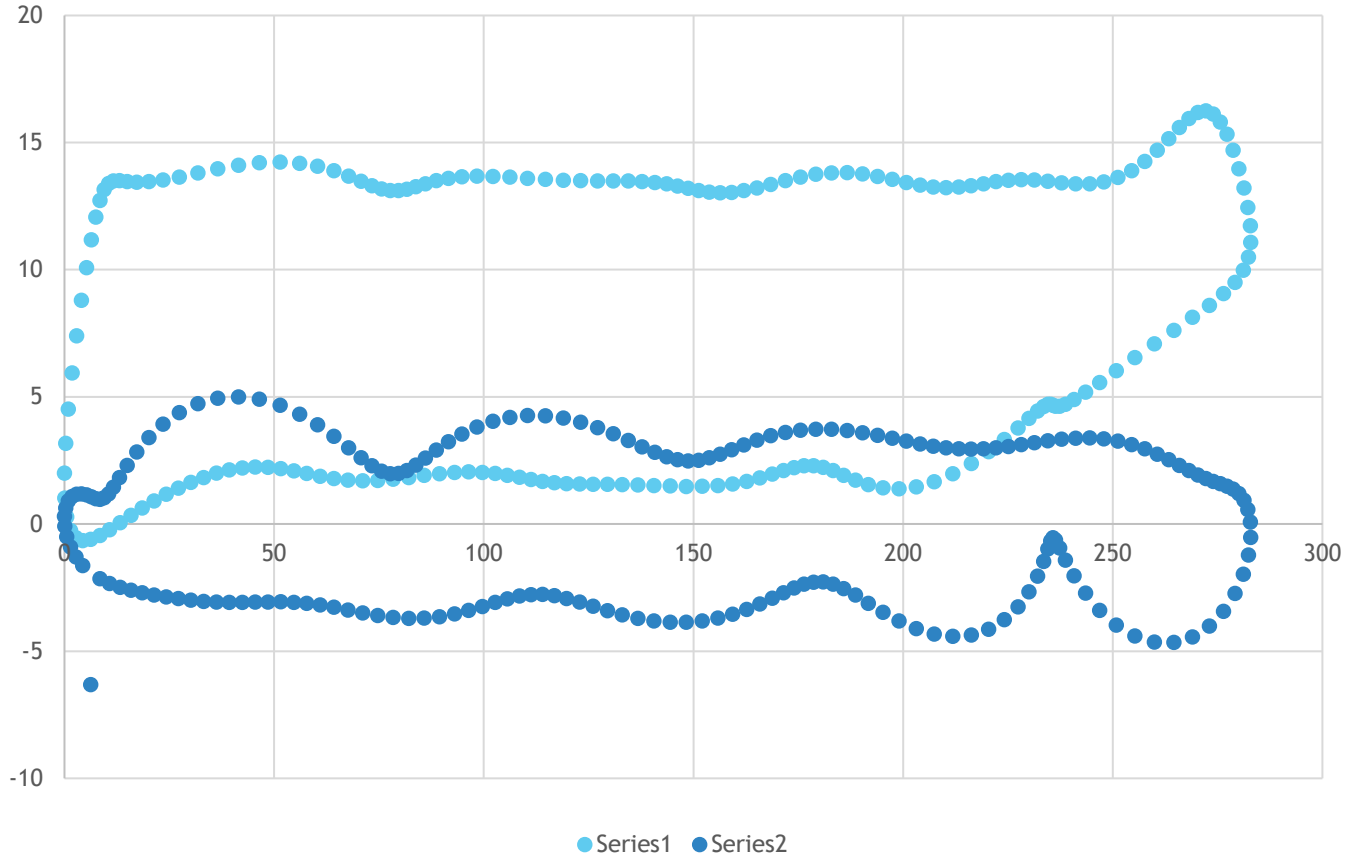


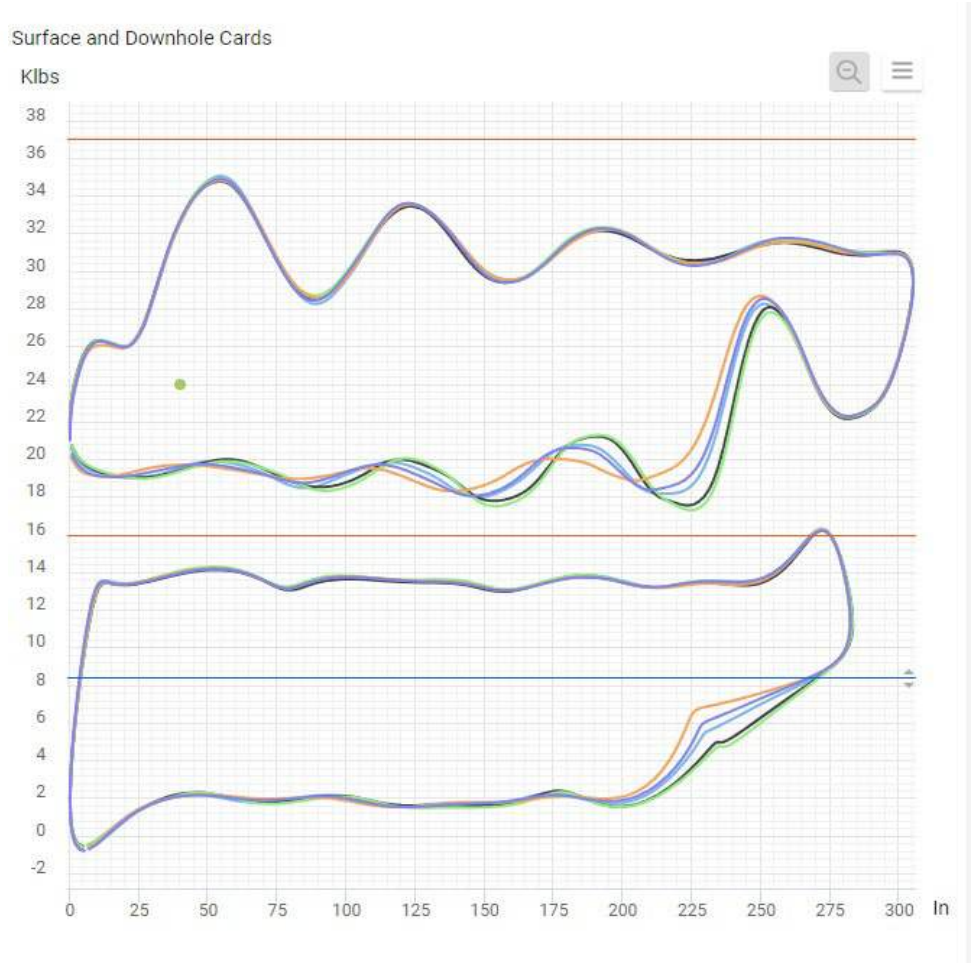
Up-stroke Zone (1) Speed:	7 SPM
Up-stroke Zone (2) Speed:	6 SPM
Down-stokre Zone (3) Speed:	4 SPM
Down-stroke Zone (4) Speed:	3 SPM
AVG SPM:	**5 SPM**





- Longstroke Pumping Unit
- Cornering Enabled
- The jump on downstroke is not the TVO it is showing the effects of the VFD speeding up on downstroke
- Jump on downstroke should be pushed to the left, passed the TVO point to optimize.





- Longstroke Pumping Unit Appears to be tagging on downstroke
- Cornering Enabled
- Plunger velocity verifies this is not a tag but the moment the drive is trying to slow down around the corner

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