Imagination at work

GE Oil & Gas
Artificial Lift Solutions

OIPA Fall Conference 2015
Chip Ollre – President, GE ESP – GE Oil and Gas
Imagination at work
Today’s Discussion

1. Quick context on GE Oil and Gas and our well lifecycle solutions
2. New technology infusion in our ESP product line
3. Global Technology Center for Oil and Gas
4. New technology development around Artificial Lift and Production Optimization
5. Q&A and Discussion
A new era for GE Oil & Gas
How we have built the company

ACQUISITION STRATEGY
FOCUSING ON HIGH-GROWTH AREAS ACROSS THE VALUE STREAM

Topside
- Nuovo Pignone (1994)
- Bently Nevada (2002)
- Salof (2013)
- Cameron Reciprocating Compression Division (2014)

Mudline
- VetcoGray (2007)
- Hydril (2007)
- Wellstream (2010)
- Naxys (2012)
- PRESENS (2012)

Well Equipment
- Sondex (2007)
- Wood Group – Pressure Control, ESP (2010)
- Dresser (2011)
- Salof (2013)
- Lufkin (2013)
Our technology solutions

Subsea Systems
- Subsea trees & wellheads
- Subsea power & processing
- Controls
- Manifolds
- Flexible risers
- Flow lines
- Specialty connectors & pipes

Drilling & Surface
- Drilling risers
- Blow-out preventers
- Electric submersible pumps
- Logging while drilling & wire line tools
- Surface wellheads & flow control
- Logging services
- Well Performance Services
  - Artificial lift solutions: Lufkin beam pumping units, electric submersible pumps, rod lift, gas lift, plunger lift, progressive cavity pumps
  - Automation and field optimization
  - Power transmission
  - Service and repair

Measurement & Control
- Asset condition monitoring, control sensing & inspection solutions
- Optimization & diagnostic software
- Pipeline inspection and integrity services
- Control & safety relief valves
- Fuel dispensers & payment terminals
- Fuel control & retail systems

Turbomachinery Solutions
- Turbomachinery equipment and services for the upstream, midstream and LNG segments including:
  - Gas turbines
  - Axial & centrifugal compressors
  - Electric motor driven compressors
  - Turn-key industrial modular solutions
  - Turboexpanders & heat exchangers
  - Contractual & maintenance services
  - Upgrades & industrial applications
  - Monitoring & diagnostics

Downstream Technology Solutions
- Equipment & services for the refinery & petrochemical, distributed gas and industrial applications including:
  - Steam turbines
  - Reciprocating compressors
  - Distributed gas solutions – small LNG & CNG
  - Pumps, valves & distribution systems
  - Blowers & compressors
  - Maintenance services & remote monitoring & diagnostics

~43,000 employees

Delivering customer solutions by applying systems-level engineering across the portfolio
Well Performance Services

Offering full range of artificial lift ... increased customer + regional coverage, applying GE R&D

Integrating automation and production optimization software ... common platform across lift technologies

Refining GE’s oilfield operating model ... closer to customers, service focus, flexible commercial models

Industry’s most compelling artificial lift portfolio ...
Wood Group ESPs + Lufkin + GE Technology ... Foundation for continued growth

Automation & Field Optimization
Optimizing Production
New Hardware and New Digital Tools
Total artificial lift solution

We are leading the artificial lift industry through innovation in technology and service models to help our customers reduce lifting costs and increase production over the life of the field.
Full Well Lifecycle Offering

- Production (bbl/d)
- ESP
- Rod lift
- Sensing, control & automation
- Oilfield power & compression
- Asset and well optimization

CAPEX
Full Well Lifecycle Offering

- Production
- CAPEX
- New Solutions Coming
  - ESP
  - Rod lift
- New Solutions Coming
- Sensing, control & automation
- Oilfield power & compression
- Asset and well optimization

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Flexible Solutions & Commercial Models

Responding to customer needs

• Well life solution for capex and production optimization

• Well optimization ... Sensors, optimization software, remote monitoring and expert consulting

• Flexible power and compression solutions

• Performance-based contracts

• Lease/rental models

Case study: Middle East Customer

• Automation + range of AL methods + intelligent platform

• Manage equipment and adjust production rates

Value

• Targeting ↑ 5% production per well

• ↑ predictability and intervention planning

• ↓ exposure to production loss and cost

2 millions bbl of additional production already achieved for this customer
New Products
Top 3 Challenges
• Abrasives
• High Free Gas Content
• Rapid Decline rates
AR Modular Pump Design

Tungsten Carbide (TC) bearing
- Radial and downthrust wear

Each module carries down-thrust load

Expanded pump operating range
- Superior downthrust protection

Expanded thrust load capacity
- Deeper setting depth applications

A total of 14 different Pump Models Available
- TD 460, 650, 1000, 1250, 1750, 2200, 3500, 4300, 6000
- TE 1550, 2700, 3300, 4200, 5500

Four important differentiators
- More Robust TC Bearing
- Beveled Insert
- Slotted Bushing
- Optimum Bearing Spacing

<table>
<thead>
<tr>
<th>Stage Type</th>
<th>BEP</th>
<th>Operating Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>TD1750 Floater</td>
<td>1750 BPD</td>
<td>800-2100 BPD</td>
</tr>
<tr>
<td>TD1750 ARM</td>
<td>1750 BPD</td>
<td>500-2100 BPD</td>
</tr>
</tbody>
</table>
Enhanced MAGS Gas separator
Tech highlights & key components

- **Gas Out, 3\(^{rd}\) stage**
- **Gas Out, 2\(^{nd}\) stage**
- **Gas Out, 1\(^{st}\) stage**
- **Intake**

**Head**

**1 stage**

**2 stage**

**3 stage**

- Compression Tube
  - TC Bearing
  - TC Bearing
  - and Vortex
Gas Handler

- 400 and 538 Series Stages
- Handles 75% of free gas without gas locking at low intake pressures
- Compression design

**Inlet Vanes – Adds Velocity**
**Discharge Veins -- Creates Pressure**

**Creates Pressure & Guides fluid to the next Impeller**

<table>
<thead>
<tr>
<th>Gas Handlers</th>
<th>BEP</th>
<th>Application Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>TD GH1400</td>
<td>1500 bbl/d</td>
<td>800-1800 bbl/d</td>
</tr>
<tr>
<td>TD GH2500</td>
<td>2650 bbl/d</td>
<td>1000-3200 bbl/d</td>
</tr>
<tr>
<td>TE GH4000</td>
<td>4500 bbl/d</td>
<td>1400-5400 bbl/d</td>
</tr>
<tr>
<td>TE GH7000</td>
<td>8000 bbl/d</td>
<td>3000-9600 bbl/d</td>
</tr>
</tbody>
</table>
TD 1000 Low Flow Mixed Flow Stage

1000 BPD Mixed Flow Stage
Available in floater, compression, AR and AR modular configurations

BEP Targets at 60 Hz
- BPD: 1080
- Ft/Stage: = 28
- Efficiency: 64%

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>TD1000 Floater</td>
<td>1000 BPD</td>
<td>700-1300 BPD</td>
</tr>
<tr>
<td>TD1000 Compression</td>
<td>1000 BPD</td>
<td>300-1300 BPD</td>
</tr>
<tr>
<td>TD1000 AR Modular</td>
<td>1000 BPD</td>
<td>300-1300 BPD</td>
</tr>
<tr>
<td>TD 1000 Wide Range</td>
<td>1000 BPD</td>
<td>300 – 1750 BPD</td>
</tr>
</tbody>
</table>
Q Plus Pump Design

Tungsten Carbide (TC) bearings
Each module carries downthrust + upthrust load
Expanded pump operating range

Lift Plus Pumps

<table>
<thead>
<tr>
<th>Abrasion Support</th>
<th>Construction Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floater</td>
<td>Compression</td>
</tr>
<tr>
<td>Radial Stabilization</td>
<td>No</td>
</tr>
<tr>
<td>Downthrust</td>
<td>No</td>
</tr>
<tr>
<td>Upthrust</td>
<td>No</td>
</tr>
<tr>
<td>Price Impact Guidelines</td>
<td>100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pump Type</th>
<th>Float Range</th>
<th>Q Plus Range</th>
<th>% Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>TD 1000 Pump</td>
<td>700 BPD to 1300 BPD</td>
<td>300 BPD to 1750 BPD</td>
<td>142%</td>
</tr>
<tr>
<td>TD 1750 Pump</td>
<td>800 BPD to 2100 BPD</td>
<td>500 BPD to 2730 BPD</td>
<td>71%</td>
</tr>
</tbody>
</table>
LIFT PLUS Q+ PUMPS

Lift PLUS Q+ 675  50–1100 BPD
Lift PLUS Q+ 1000  300–1750 BPD
Lift PLUS Q+ 1750  500–2730 BPD

ESP TD1000 QPlus
Pump Performance Curve for ESP TD 1000 QPlus
1 stage @60Hz 3500 RPM Specific Gravity 1.0

Operating Range
ARI CMP/CMP/ARI MDLR

Q PLUS

Operating Range
ARI CMP/CMP/ARI MDLR

BEP Data
Q = 1,080 bbl/d
H = 302 ft
P = 0.39 HP
E = 61.3%

Capacity (bbl/d)
0 250 500 750 1,000 1,250 1,500 1,750 2,000

0.80
0.60
0.40
0.20
0.00
Efficiency (%)

Power (HP)

0 10 20 30 40 50

Efficiency

Power

Head

Head (ft)

Compressor/Anti-Modular

Float

Operating Range
ARI CMP/CMP/ARI MDLR

Diffuser

Impeller

Downthrust TC bearing

Upthrust TC bearing

Tech Day
New TD675 Low Flow Mixed Flow Stage

675 BPD Mixed Flow Stage
BEP Targets at 60 Hz
- BPD: 675
- Ft/Stage: ≥ 25
- Efficiency: 58%

<table>
<thead>
<tr>
<th>Stage Type</th>
<th>BEP</th>
<th>Operating Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>TD 675 Floater</td>
<td>675 BPD</td>
<td>500 to 850 BPD</td>
</tr>
<tr>
<td>TD 675 Compression</td>
<td>675 BPD</td>
<td>50 to 850 BPD</td>
</tr>
<tr>
<td>TD 675 AR Modular</td>
<td>675 BPD</td>
<td>50 to 850 BPD</td>
</tr>
<tr>
<td>TD 675 Q+</td>
<td>675 BPD</td>
<td>50 to 1100 BPD</td>
</tr>
</tbody>
</table>
Power to Lift™ system

A fast, modular, and flexible power solution for evolving artificial lift needs

Applications
• Areas where there is no pre-existing power infrastructure and capacity
• When power assurance is uncertain or power requirements are difficult to predict

Advantages
• Powered by well gas
• Provides power, power management & artificial lift
• Single package modular design
• Multi-well capabilities
• Communication & control solutions for smarter operation
• Flexible power range
• Environmentally efficient

Limitations
• Well gas must be present in sufficient quantities
New Technology Center
The GE Global Oil & Gas Technology Center

- 130 technical professionals
- $125MM investment
- Summer 2016 completion date
- 9th global research site
- Locally designed and locally built
- 70% Complete (October ‘15)
An office built around a lab

- Collaborative Working Environment
- Indoor Labs
- Customer Collaboration Space
- Showroom
- Test Wells

Architect Rendering
High Bay Lab
Visible artificial lift flow loop will be installed along the wall
Downtown OKC Location Context
OGTC Research Programs

Production Systems
- Artificial Lift
- Production Optimization
- Lifecycle Management

Well Construction Systems
- Intelligent Completions
- Brilliant Drilling Systems
- Sensing & Informatics

Energy Systems
- Full Ecosystem Optimization
- Gas Monetization
- Oilfield Power Systems

Water and Oilfield Sciences
- Secondary Water Treatment
- Flow Assurance
- Environmental Sensing

CO2 & Reservoir Performance
- EOR
- Alternative Stimulation Fluids
- CO2 Oilfield Supply

Geotechnical Center of Excellence
- Reservoir Engineering & Simulation
- Environmental
- Regulatory
- Hydrology
- Geophysics
- Geology
- Rock Mechanics & Petrophysics
In Closing

1. GE has the scale, technical capability, and expansive portfolio to support modern production optimization
2. The technology infusion in our ESPs will continue to deliver results to your base production
3. Our Global Technology Center is off and running; we look forward to working with you
4. Please stay in touch with our team so we can share with you our upcoming developments with our new technology
Thank you for your time.

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(832) 875–5675  
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Questions or Contacts on the Global Technology Center  
Taylor Shinn  
(405) 219-9203  
taylor.shinn@ge.com
Additional Context & Support
# PCP Product Family

## Electric Wellhead Drives
- **Models:**
  - M-2100 40Hp
  - G-2100 60Hp
  - L-2100 75Hp
  - D-2100 (single motor 100Hp) (dual motor 150Hp)

## Hydraulic Wellhead Drives
- **Models:**
  - (Belt Driven)
    - H-2000 60Hp
  - (Beltless Gear Driven)
    - M-2100 40Hp
    - L-2100 75Hp
    - G-2100 100Hp

## Integral Flow Tee/BOP
- **Features:**
  - Combination Blow Out Preventer and Flow Tee
  - Various flange sizes available
  - Various port sizes available
  - Optional Polish Rod Lock Out Rams available
  - Provides rigid connection for wellhead drive

## PC Pumps
- **Features:**
  - Available in a wide range of volumes and lift capacities
  - Specific geometries available for sand applications
  - Several elastomer compounds for diverse applications
  - Options available for rotor base materials and coatings

## Common Features:
- Proven Back-Spin Brake
- Superior Primary Sealing System
- No Polish Rod Wearing Secondary Seal
- High Axial Load Ratings
- Flanged Wellhead Connection
- Rigid Motor Mount With Simple Adjustment

![Image of Electric Wellhead Drives](image1)
![Image of Hydraulic Wellhead Drives](image2)
![Image of Integral Flow Tee/BOP](image3)
![Image of PC Pumps](image4)

**Diagram:**
- **Stator**
- **Rotor**
## Pump components

<table>
<thead>
<tr>
<th>Top Lock</th>
<th>Bottom Lock</th>
<th>Tubing Pumps</th>
<th>YP Frac</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Insert pump</td>
<td>• Insert pump</td>
<td>• Larger production</td>
<td>• Eliminates dead space between</td>
</tr>
<tr>
<td>• Not for deep wells</td>
<td>• Good for deep wells</td>
<td>• Barrel ran on tubing</td>
<td>adapter discharge ports and leading</td>
</tr>
<tr>
<td>• Best for gassy wells</td>
<td>• Often require strip</td>
<td>• Most common</td>
<td>edge of plunger</td>
</tr>
<tr>
<td>• Easier to unseat</td>
<td>out</td>
<td>• Can be wild standing or</td>
<td>• Wiper/seal wear is reduced by 50%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>positive standing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Slimhole</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Quinn in-house chrome plating shop and WellTrack™ software provide unparalleled reliability and well-tracking.
Technology growth – YP Frac Pump

*Designed for increased efficiency*

- Eliminates dead space between adapter discharge ports and leading edge of plunger
- Wiper/seals promote continuous wiping of barrel internal diameter on both upstroke and downstroke
- Wiper seals are pressure activated independently on upstroke and downstroke
- Wiper/seals center the plunger within barrel I.D. promoting even barrel and plunger wear
- Wiper/seal wear is reduced by 50%
- Wiper/seals reduce fluid slippage thereby increasing efficiency
Reciprocating pump facilities, Canada

New chrome plating facility

• $25MM investment – Finished October 2013

• State of the art operation
  – Fully self contained
  – Minimal waste streams
  – Purified water
  – Compressed dry solid waste
  – Digitally controlled process
Surface pumping systems
Proven pumps with unmatched support

Applications
• Water injection/disposal
• Transfer and boosting of crude/NGL/water
• Gas treatment (i.e. Ammine recirculation)
• Refinery wash-water
• Mining dewatering
• Offshore

Advantages
• Motor range ~50HP-2000HP
• VFD, DOL or Softstarter
• Mechanical sealing system (various API plans available)
• Skid-based

Limitations
• Large footprint
• Solids handling
Surface pumping systems

**Upstream**
- Water injection/disposal
- CO2 and water flood (EOR)
- LACT pumps
  (lease automatic custody transfer)

**Midstream**
- Crude transfer and boosting
- NGL transfer and boosting
- Water transfer and boosting

**Downstream**
- Gas treatment (i.e. amine recirculation)
- Refinery wash-water

**Mining and storage**
- Mining dewatering
- Water supply and transfer
- NGL injection and storage (cavern storage)
- Salt dome cavern leeching and storage

**Offshore**
- FPSO crude transfer and water injection
- Platform transfer and injection pumps
- Recirculation applications
- Seawater injection applications

<table>
<thead>
<tr>
<th>SPS Ranges quick glance</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP range</td>
<td>50</td>
<td>2000</td>
<td>HP</td>
</tr>
<tr>
<td>Flow range BPD</td>
<td>170</td>
<td>102,000</td>
<td>BPD</td>
</tr>
<tr>
<td>Flow range GPM</td>
<td>5</td>
<td>3000</td>
<td>GPM</td>
</tr>
<tr>
<td>Flow range M³/HR</td>
<td>1</td>
<td>675</td>
<td>M³/HR</td>
</tr>
<tr>
<td>Pressure range?</td>
<td>10,000</td>
<td></td>
<td>PSI</td>
</tr>
</tbody>
</table>

**Efficiency quick glance**

<table>
<thead>
<tr>
<th>Efficiency quick glance</th>
<th>% eff. @ BEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>525 GPM (18,000 BPD)</td>
<td>80%</td>
</tr>
<tr>
<td>1500 GPM (51,428 BPD)</td>
<td>85%</td>
</tr>
<tr>
<td>2500 GPM (85,714 BPD)</td>
<td>86%</td>
</tr>
</tbody>
</table>
SPS packages

- Motor range ~50HP-2000HP
- VFD, DOL or Softstarter
- Mechanical sealing system - (various API plans available)
- Skid
- Instrumentation
  - RTDs for bearing and lubrication temperature
  - Vibration transmitters
  - Suction and discharge pressure transmitters
  - Flow meters
  - Custom instrumentation
Patent pending quick service option

Dual access mounting system

- Bi-directional seal removal
- Thrust chamber removal without disturbing pump/motor
- Service flexibility
- Less downtime/reduced service charges for customer
- Improved and standardized components
Rod lift product portfolio

Rod Lift
Drive new levels of efficiency, productivity and value with a full complement of industry-leading beam and hydraulic rod lift units, precision engineered to meet and exceed expectations. Expert installation and aftermarket parts, repair, and services ensure safe, optimized operations.
Lufkin beam pumping units

“The workhorse of the oil field”

Applications
- Pump depths up to 16,000 ft
- Volumes from 1-6,000 BBD
- Wells with low bottom hole pressures

Advantages
- Proven, tested design
- Extremely reliable
- Can produce very efficiently
- Variety of models available
- Products backed by a network of installation, service, and repair expertise

Limitations
- When very high flow rates are needed
Lufkin beam pumping systems

<table>
<thead>
<tr>
<th>Conventional</th>
<th>Mark II</th>
<th>Air Balanced</th>
<th>Low Profile</th>
<th>Reverse Mark</th>
<th>Portable Roadrunner</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Simple operation</td>
<td>• Available in 50 different sizes</td>
<td>• Approximately 35% shorter and 40% lighter than crank-type units</td>
<td>• Designed for installation in fields irrigated by traveling sprinkler systems or in urban areas</td>
<td>• Improved alternative to the conventional type geometry</td>
<td>• Can be erected and fully functional in a few minutes at the well site</td>
</tr>
<tr>
<td>• Minimum maintenance</td>
<td>• Unique geometry that can reduce torque up to 35% and deliver lower power costs</td>
<td>• Ideal for use as portable or test</td>
<td>• Reduced torque and power requirements on many pumping applications</td>
<td>• Can be installed on piling or superstructures</td>
<td>• Trailer-mounted self-contained conventional pumping unit that lowers for legal highway transport</td>
</tr>
<tr>
<td>• The “workhorse” of the oil field</td>
<td>• Can be installed on piling or superstructures</td>
<td>• Low profile feature makes for a more compact footprint</td>
<td>• Minimum maintenance</td>
<td>• The “workhorse” of the oil field</td>
<td></td>
</tr>
</tbody>
</table>

Lufkin specializes in appropriate geometries for well conditions that minimize loads and maximize production
Hydraulic lift technology

**Improved control**
Pressure/polished Rod load

**Smart cylinder**
Internal linear Transducer for Complete control

**Direct mount design**
Connects to 2-9/16” API flange

**Internal sucker Rod connection**
Oilfield automation

Increasing well production, reducing electrical costs, improving uptime, and cutting maintenance costs through technology and services

Field automation
- Pump-off controllers
- Injection well controllers
- Progressing cavity pump controllers
- Variable speed drives
- Motor control panels
- Design/analysis software

Well monitoring
- Artificial lift and reservoir monitoring systems
- ESP bypass systems
- Auto flow valves
- Dual ESP completions
- Remote Monitoring
- Predictive Analytics

Optimization
- Consulting
- Production
- Reservoir
- Power
- Run life

Field Vantage™
Automation
Optimized artificial lift equipment and well performance

**Equipment automation**
Continuous monitors equipment data to ensure performance and reliability
- Lufkin Well Manager (LWM)
- Pump-off controllers
- Injection well controllers
- Progressing cavity pump controllers
- Variable speed drives
- Motor control panels
- Design/analysis software

**Well monitoring**
Monitors and optimizes artificial lift equipment and performance for enhanced production
- Artificial lift and reservoir Monitoring systems
- ESP bypass systems
- Auto flow valves
- Dual ESP completions
- Field Vantage™ auto well surveillance system
- Z-Trendz data management

**Data management**
Data management and wireless transmission
- Pipeline SCADA systems
- Wellhead control systems
- Platform automation
- Pipeline management solutions
Field Vantage™ solutions

Without Field Vantage

- Suboptimal production
- Unplanned failure
- Returned to suboptimal production

- Expected well production
- Long unplanned workover

With Field Vantage

- Early failure detection
- Extend run life
- Optimize production
- Short planned workover

Visualize

Predict

Optimize

Data-driven insights that empower you to make better decisions faster—enabling results such as production gains of 5-8%
Field Vantage™ solutions

• **Advanced Services** GE’s highly experienced Production Consultants, Advisory Services, and on-site field service engineers help customers get the most of technology and maximize outcomes.

• **Optimization and Predictive Analytics** When operations are transformed from reactive to proactive, and pumps run for optimal flow, operators eliminate the risk and variability of meeting and exceeding production targets.

• **Instrument and Connect** Operators are more effective when they can visualize operational data gathered with high integrity, transmitted reliably and presented for the way they work—anywhere and on any device.

Move from reactive to predictive, proactive operations
Field Vantage™ prognostics

*Reactive to proactive*

GE Field Vantage Chicago Monitoring Capabilities

- **160+** Units
- **4000+** Assets
- **100k+** Sensors
- **40+** Reports
- **35+** Calls
- **40+** Actionable Notifications

Multiple sensors compared thresholds exceeded result in advisories

Monitoring center tracks issues and reports weekly

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Field Vantage™ prognostics

Reactive to proactive

ESP bearing failure example

- Nov ‘11 Pump install
- Jan 1, 2012 high vibration indication
- Jan 12, 2012 very high priority 3 vibration indication. Decided to slow ESP down
- Mar 1, 2012 persistent priority 4 vibes
- Apr 9, 2012 pump speed increase high vibes return after
- Apr 30, 2012 pump failure