Sucker Rod Pumping Workshop
Wyndham Hotel, Houston, Texas
September 11 – 14, 2007

Sucker Rod System Analyst

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H & H WELL SERVICES, LLC
Computerized Diagnostic Testing Services
Role of Sucker Rod System Analyst

1. Time Requirement is about 45 minutes per well.
2. Analyze collected data at the well.
3. Make recommendations to fix problems discovered.
4. Record work necessary to fix problem as notes.
5. When recommended changes are completed, new data should be collected once the well has stabilized.
6. Notice if well performance changed as planned.
7. Follow-up on recommendations to learn from successes and failures.
8. Role changes from a data collector to a knowledgeable well analyst and problem solver.
Well Analysis Identifies the Problem

Inflow Performance
- Pump Performance
- Mechanical Loading
- Prime Mover
- System Efficiency Analysis
- Root Cause of Failure
- Data Trends Over Time
  - Has Well’s Production Changed?
  - Has the Fluid Level Changed?
- Dynamometer

Goal is to answer the WELL PERFORMANCE QUESTIONS
What Well Information Should be Known in Order to Analyze a Well?

- Wellbore description
- Artificial Lift System Design
- Recent and/or Representative Well Test
- Pump Capacity (or, Pump Card)
- Producing BHP & Static BHP
- Current Production Equipment Setup
- Energy Efficiency
- Fluid Properties
- Past History
Different Units – Same Info Required
Record Observations at the Well

Consistency in Approach

- Use Check List
- Motor Info
- PU Info
- Site Condition
- Noticeable Leaks
- Is Fluid going into the tank
Key Observations at the Well

- Tubing and Casing Pressure Readings
- Is Produced Fluid Warming the Flow Line
- Is Polished Rod Hot to the Touch
- Hear any Unusual Noises at the Well
- Are Belts, Polished Rod, or Pumping Unit Shaking or Vibrating
- Are Downhole Impact Loads Shaking the Ground
- Can the Pump Pressure up the Tubing
- Does this Tubing Pressure Leak Off
Record what you see
Problem Shown w/ Digital Camera

Dynamometer Cards Appear to be OK

Fo Max

Fo From Fluid Level

Wrf

Wrf + Fo Max

74.8
Normal 7 SPM Slows to 3 SPM Due to Rod Heavy Imbalance

![Graph showing the change in SPM from 7 to 3 due to rod imbalance. The graph indicates a 6 seconds period of normal SPM followed by 4 seconds of reduced SPM.]
Common Practices that Result in Operational Problems

- Need to tag in-order to pump.
- Disabled POC Controller - set on hand and running 24 hrs/day.
- Increase SPM in Order to Maintain Production.
- Increase SPM because Fluid Level is above the pump.
- Pull the Well, because no Fluid in the Tank.
- Wells Produce into Common Tank, no good test data.
ACOUSTIC SURVEYS ANSWER FOLLOWING QUESTIONS IN ORDER TO ANALYZE A WELL:

1. What is the depth to the top of the liquid?
2. Does liquid exist above the pump?
3. What is the percentage of liquid in the annular fluid column?
4. Does the liquid in the casing annulus restrict production?
5. What is the casing-head pressure? Does it restrict production?
6. Is gas flowing up the annulus? At what rate?
7. What’s maximum production rate available from well?
Wellbore Reflections shown in Fluid Level

1. Acoustic Fluid Level and Pressure Build-up are used to answer Questions

2. The Depth from the gun to an anomaly in the casing annulus reflect back to the microphone at the surface.

3. Microphone housed in the gas gun detects the blast from the shot and reflected sound from collars, liners, perforations, liquid level, plus other obstructions in the annulus.
Acoustic Liquid Level Test Analysis

- Potential: Oil: 30.2 BBL/D, Water: 435.9 BBL/D, Gas: 8.3 Mscf/D
- IPR Method: Vogel
- PBHP/SHBP: 0.13
- Producing Efficiency: 95.9%
- Fluid Densities: Oil: 33 deg.API, Water: 1.02 Sp.Gr.H2O, Gas Gravity: 0.94 Air = 1
- Acoustic Velocity: 1072.39 ft/s
- Casing Pressure: 51.6 psi (g)
- Casing Pressure Buildup: 0.3 psi, 2.00 min
- Gas/Liquid Interface Pres.: 61.9 psi (g)
- Liquid Level: MD 4371.07 ft
- Formation Depth: MD 4865 ft
- Annular Gas Flow: 4 Mscf/D
- % Liquid: 79
- Pump Intake Pressure: 175.6 psi (g)
- PBHP: 218.0 psi (g)
- Reservoir Pressure: 1722.3 psi (g)
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
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<tbody>
<tr>
<td>1. Is the well pumped off?</td>
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<td>2. What is the pump intake pressure?</td>
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<td>3. What is the pump fillage? And pump displacement?</td>
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<td>4. What is the current pumping speed?</td>
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<td>5. Are the traveling and/or standing valves leaking?</td>
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<td>6. Are the maximum and minimum rod loads within limits?</td>
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<td>7. What is the polished rod and pump horsepower?</td>
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<td>8. Gearbox overloaded? Is the unit properly balanced?</td>
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<tr>
<td>9. Required counterweight movement to balance the unit?</td>
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<tr>
<td>10. Is the downhole gas separator effective?</td>
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Use Any of these Transducers to Perform a Dynamometer Survey

Safe & Quick

Accurate
1) Diagnostic dynamometer surface cards used for Diagnosing Sucker Rod Pumping Systems.

2) Pump dynamometer card is to identify and analyze downhole problems.

3) Spike load at 49.5 inches on Stroke #20 shows when the plunger stopped on the upstroke. Unusual shape occurs over a 1 second time period and represents 1850 lb load increase required to overcome the downhole friction.
15 inches of Surface Stroke (73-88 inches on Upstroke) Lost to Rod Stretch in-order to apply Force to overcome Sudden 1850 lbs of Unknown Friction on Rods and Plunger

Plunger Stop for 1 Second

Plunger Velocity
Valve Check Load Tests Answer Following Questions in Order to Analyze a Well:

1. What rate does the Traveling Valve Leak?
2. What is the condition of the traveling valve, the pump barrel and plunger and the tubing string?
3. Is the fluid being held in the tubing?
4. Does the Standing Valve Leak?
5. Are the rod string lengths correct?
Stop on the Down Stroke to Monitor for Leakage from the Pump into the Casing

Standing valve test taken during the down stroke by gently stopping about \( \frac{1}{4} \) from the bottom of the stroke.
Stop on the Upstroke to Monitor for Leakage from the Tubing into the Pump

**TV Check Load Test**
weights the rod string buoyed in tubing fluid plus the fluid load acting on the traveling valve (across plunger).
Measured and Computed Valve Loads
TV Load Loss function of Pump-Barrier Clearances

New Pump 0.006 Clearance

TV Check Approx. 22 BPD Leakage
On site Power Survey Answer Following Questions In Order to Analyze a Well:

1. What is the apparent motor current?
2. What is the real motor current?
3. What is the power use during a pump stroke?
4. What is the exact power consumption, KWH/day, $/month, $/Bbl, etc?
5. Is the motor over/under sized for the load?
6. What is the power factor?
7. Is the Unit electrically balanced?
8. Does the motor performance require more detailed analysis?
9. What is the Torque loading?
10. What movement of the weights is required to electrically balance the unit?
11. What is total system efficiency?
Power Measurement Equipment

1. Acquire:
   - RMS (thermal) motor current
   - Average (real) motor current
   - kW during a pump stroke cycle.

2. Three voltage sensing leads
   - RIGHT
   - CENTER
   - LEFT

3. Two current sensors.
Electric Power (kW) and Current (Amps) Input to the Motor over the time of One Pump Stroke

Dyna Cards | Torque | Rod Loading | Load/Current | Power Torque | Power Results
Select Left Axis: Power [kW] | Select Right Axis: Current [Amp]
Select Horizontal Axis: Elapsed time [Sec] | Base Right Axis Data Off Left Axis

Indicator Movement Control

| ← Backward | Forward → | Power (kW) | Stroke |
| Place Indicator on last point. | Current (Amp) | 14.38 | 15 |
| Elapsed time (Sec) | 2.73 | 0.92 | ? | < Pg Up | Pg Dwn >
To be a Successful Well Analyst

- Must Use Data to Determine the Solution to Well Problem’s.....

- Needs to look 10,000 feet down a 3 inch diameter black hole and “SEE” what is happening ......

- People often think you are a Wizard

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QUESTIONS?
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