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

Pumping Flumping Sucker Rod Lifted Wells

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What is a Flumping Sucker Rod Lifted Well

1. **Flumping** - the well is flowing fluids to the surface up the casing annulus, plus at the same time fluids are being lifted up the tubing to the surface.

2. Oil wells flump because:
   - High producing bottom hole pressure and/or
   - High gas rate flowing up the casing annulus; lightening the fluid column above the formation.

3. Flumping often continues for long time period until the gas rate decreases or producing bottomhole pressure decreases.
Possible Solutions to Flumping

1. Back-pressure Valve
   - Backpressure on Tubing
   - Backpressure on Casing Annulus

2. Try to Keep Most of Gas out of Tubing
   - Downhole Gas Separator
   - When possible, set the pump below the perforations

3. Use a specialty pump such as a VSP® pump to discharge gas into tubing.

4. Use longer stroke length to increase compression ratio

5. Space out the pump to minimize dead space at bottom of stroke
Well Flowing off Tubing and Casing With Fluid Level at/near Surface: Poor Pump Action & Low Production Rate

Initially Flowing:
600 BWPD, 200 BOPD, 600 MscfD

Currently:
9 BWPD, 1 BOPD, 150 MscfD

Tbg Fluid Grad. 0.134 psi/ft
Symptoms of Well Flowing up Tubing and/or Casing: Measured TV and SV loads Approximately Equal

Measured TV Load
High Due Light Flowing Tubing Gradient

Used Normal Gradient 0.445 psi/ft
Flumping Well Bore Description

Pump Depth: 4509.7'
Pump Displ. >350 BPD

Perforations:
8376-8380, 8384-8388'
8412-8418, 8420-8428'

Poor Boy Gas
Separator:
1"x18' Dip Tube
2 7/8" Slotted Pup
Area = 3.9 sq. in.

Liquid Capacity: 195 BPD

Sept. 11 - 14, 2007

Rodded up on 5/17/07

Spud Date: 5/17/07
Completion Date: Dec-99
GL Elev: 12
KB Elev: 12

Elevation 12'

Tubing Detail

<table>
<thead>
<tr>
<th>Tubing</th>
<th>Elev</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>142 JTS 2-3/8&quot;</td>
<td>4376.77</td>
<td>4366.77</td>
</tr>
<tr>
<td>2-3/8&quot; 4-1/2&quot; TAC</td>
<td>3.02</td>
<td>4391.79</td>
</tr>
<tr>
<td>3 JTS 2-3/8&quot; J-56</td>
<td>88.68</td>
<td>4480.47</td>
</tr>
<tr>
<td>2-3/8&quot; pup</td>
<td>4.03</td>
<td>4484.50</td>
</tr>
<tr>
<td>1-3/4&quot; Working BBL Pump</td>
<td>24.10</td>
<td>4508.60</td>
</tr>
<tr>
<td>SN</td>
<td>1.09</td>
<td>4509.69</td>
</tr>
<tr>
<td>2-3/8&quot; x 2-7/8&quot; x 0</td>
<td>0.74</td>
<td>4510.43</td>
</tr>
<tr>
<td>2-7/8&quot; Slotted Pup</td>
<td>4.15</td>
<td>4514.58</td>
</tr>
<tr>
<td>1 JT 2-7/8&quot; tubg</td>
<td>32.42</td>
<td>4547.00</td>
</tr>
<tr>
<td>B.P.</td>
<td>0.71</td>
<td>4547.71</td>
</tr>
<tr>
<td>EOT</td>
<td>4547.71</td>
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Rod Detail

<table>
<thead>
<tr>
<th>Rod</th>
<th>Elev</th>
<th>12</th>
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<tbody>
<tr>
<td>1-1/2&quot; Polished Rod</td>
<td>26.00</td>
<td>38.00</td>
</tr>
<tr>
<td>1 - 7/8&quot; x 4' pony</td>
<td>4.00</td>
<td>42.00</td>
</tr>
<tr>
<td>79 7/8&quot; Norris 97 sucker rods</td>
<td>1975.00</td>
<td>2017.00</td>
</tr>
<tr>
<td>94 - 3/4&quot; Norris 97 sucker rods</td>
<td>2350.00</td>
<td>2437.00</td>
</tr>
<tr>
<td>6 - 1-1/2&quot; weight bars</td>
<td>150.00</td>
<td>4517.00</td>
</tr>
<tr>
<td>5&quot; x 1-3/4&quot; plunger</td>
<td>5.00</td>
<td>4522.00</td>
</tr>
</tbody>
</table>

Pump Detail

1-3/4" Working BBL Pump
1-3/4" x 5' plunger
1" x 10' gas anchor

Casing Detail

4 1/2" 11.5# J-55 LTC @ 8862'
Prevent Flumping Up The Tubing by Using a Back-pressure Valve

Gas Flowing through Pump OR Pumped into Tubing

- Back-pressure valve maintains high tubing pressure to prevent gas from blowing all of the liquid out of tubing
- Without BPV Pump action erratic & discharge may STOP

<table>
<thead>
<tr>
<th>Flow</th>
<th>Spring Force</th>
<th>Pressure Gage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Increase Pressure by Compressing Spring</td>
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</tbody>
</table>

BPV

Harbison-Fischer Model Illustrated
Used Back-pressure Valve to Increase Tubing Pressure to 300 – Water up Tubing & Oil up Casing

Stabilized One Week Later:
320 BWPD, 42 BOPD, 124 MscfD

Tbg Fluid Grad. 0.455 psi/ft
Week Later Back Pressure Test
Slight Tag Due to Increased Static Stretch

0.202 Psi/Ft Tbg Fluid Gradient
### Summary of Adding Pressure to the Tubing by Using a Back-pressure Valve

Increasing Back-pressure to prevent gas from blowing tubing “dry”: increases HP, reduces SPM, increases rod load, caused slight tag, and reduces pump displacement.

<table>
<thead>
<tr>
<th>Tubing Head Pressure (Psig)</th>
<th>Estimated Tubing Fluid Gradient (psi/ft)</th>
<th>Fluid Load on Pump (Lbs)</th>
<th>Polished Rod HP</th>
<th>Strokes per Minute</th>
<th>Effective Pump Disp. BPD</th>
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<tbody>
<tr>
<td>250</td>
<td>0.160</td>
<td>2337</td>
<td>6.3</td>
<td>8.74</td>
<td>381.0</td>
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<tr>
<td>500</td>
<td>0.187</td>
<td>2700</td>
<td>7.7</td>
<td>8.14</td>
<td>334.1</td>
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<tr>
<td>750</td>
<td>0.202</td>
<td>3461</td>
<td>8.9</td>
<td>7.83</td>
<td>312.4</td>
</tr>
<tr>
<td>1000</td>
<td>0.202</td>
<td>3893</td>
<td>8.8</td>
<td>7.11</td>
<td>293.4</td>
</tr>
</tbody>
</table>

Ratio 1000 to 250

| 1.666 | 1.397 | 0.814 | 0.770 |
Different Well ~ First Survey: 5.7 SPM Everything Looks A-OK

Current Production: 25 BWPD, 180 BOPD, 300 Mscf/D

Fo Max

Wrf + Fo Max

Wrf

Fo From Fluid Level

217 BPD
147 in.
Well Survey 5-Days Later 7.0 SPM:
Flowing Up Tbg & Csg w/ High Fluid Level

Casing Pressure
81.2 psi (g)
Casing Pressure Buildup
1.5 psi
2.00 min
Gas/Liquid Interface Pres.
84.5 psi (g)
Liquid Level Depth
MD 1083.11 ft
Pump Intake Depth
MD 8050.00 ft
TVD 8050.00
Formation Depth
MD 8609.00 ft

Well State:
Producing
Annular
Gas Flow
102 Mcf/D
% Liquid
30

Liquid Below Tubing
Oil 0 %
Water 100 %
% Liquid Below Tubing 42 %

Pump Intake Pressure
775.1 psi (g)
PBHP
880.8 psi (g)
Reservoir Pressure (SBHP)

Stroke 20
Wrf
Wrf + Fo Max
Fo Max
Well Survey 5-Days Later 7.0 SPM: Flowing Up Tbg & Csg w/ High Fluid Level

--- NO PUMP ACTION ---

All of the Rest of the Strokes

Fo Max

Wrf + Fo Max

Wrf

168.0-2.50
0
2.50
5.00
7.50
10.00
12.50
15.00
17.50
20.00

Casing Pressure: 83.6 psi (g)
Casing Pressure Buildup: 11.1 psi, 5.00 min
Gas/Liquid Interface Pressure: 87.0 psi (g)
Liquid Level Depth: MD 1083.11 ft
Pump Intake Depth: MD 8050.00 ft, TVD 8050.00
Formation Depth: MD 12000.00 ft

Producing
Annular Gas Flow: 470 Mscf/D
% Liquid: 22
Oil: 0 %
Water: 100 %
% Liquid Below Tubing: 35 %

Pump Intake Pressure: 597.7 psi (g)
Reservoir Pressure (SBHP): blank

Liquid Below Tubing...
Installed Variable Slippage Pump and Downhole Gas Separator

6.08 SPM

Wrf + Fo Max

Wrf

Fo Max

Fo From Fluid Level

223 BPD

140 in.

Casing Pressure
10.1 psi (g)

Casing Pressure Buildup
0.054 psi
3.00 min

Gas/Liquid Interface Pres.
16.4 psi (g)

Liquid Level Depth
MD 7008.80 ft

Pump Intake Depth
MD 7988.00 ft
TVD 7988.00 ft

Formation Depth
MD 8609.00 ft

Annular
Gas Flow 3 Mcf/D

% Liquid 96

Liquid Below Tubing
Oil 0 %
Water 100 %

% Liquid Below Tubing 96 %

Pump Intake Pressure
333.7 psi (g)

PBHP
605.6 psi (g)

Reservoir Pressure (SBHP)

Well State:
Producing

Spacing at the well site:

a. Touch bottom with tubing loaded with fluid
b. Pick up overtravel length
c. Pick up spacing allowance, normally 12"
d. The lower end of the plunger should slightly enter the start of the VSP® taper. This position gives the least amount of bypass slippage. After well has stabilized, space the plunger higher in small increments for more bypass slippage to achieve desired results.

Re-space well as needed after stabilized:

a. Lower rods for a light tag at pump, then raise slightly for stroking close to bottom without entering VSP® taper.
b. After accomplishing raise rods in 6 inch increments until bottom of plunger enters taper.

"Spacing allowance: 30" down to 4,000 feet well depth, then add 6" for every 1,000 feet well depth below 4,000 feet."
Re-Spaced VSP

Raised 7 more inches
7 Months Later Fluid Level @ Pump
Need to Control Run Time

Casing Pressure
52.4 psi (g)
Casing Pressure Buildup
3.4 psi
5.00 min
Gas/Liquid Interface Press.
72.7 psi (g)
Liquid Level Depth
MD 7992.15 ft

Well State:
Producing

Annular
Gas Flow
120 Mscf/D
% Liquid
28

Liquid Below Tubing
Oil 0 %
Water 100 %
% Liquid Below Tubing 28 %

Pump Intake Pressure
72.7 psi (g)
PBHHP
151.4 psi (g)
Reservoir Pressure (SBHP)

Fo Max
Fo From Fluid Level

Wrf + Fo Max
Wrf

6.08 SPM
91 BPD
67 in.

7 Months Later Fluid Level @ Pump
Need to Control Run Time
Observations

- **Gassy Wells Difficult to Pump**
- **Back-pressure Valve on Tubing Improved performance of these Rod Pumped Wells**
- **Too much Back-pressure Detrimental to Operation of Sucker Rod Lifted Well**
- **Wells that will Flump can Produce more Liquids than Pumping up Tubing Alone.**
- **Poor Boy Gas Separators did not keep Gas out of the Tubing**
- **VSP® used effectively to Drawdown Well**
Production Methods Used to Produce Flumping Wells

1. Set the pump intake as deep as possible.
2. Set the pump in the rat hole, if one exist.
3. If no rat hole, run an improved gas separator.
4. Increase pump compression ratio with long stroke length.
5. Space out the pump to minimize dead space at bottom of stroke.
6. Use a specialty pump such as a VSP® pump to handle gas.
7. Use a backpressure valve on the tubing and sometimes on casing, if pump action erratic or stops.
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