Solar Powered Beam Pumping
Unloading Liquid from Gas Wells

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Solar Powered Beam Pumping

Developed as Windmill Replacement

CBM 3882 in-lb

C-8-12.5-28

DC Motor 1/3 HP

Developed as Windmill Replacement
8 ft x 8 ft Solar Panels

1. Charge Deep Cycle Battery Pack
2. Sun Tracking Capability
3. 64 Sq Ft Panels Provides 370 amp-hours
4. 1/3 Hp Electric DC Motor will drive pumping system 1 month without sun light
8 Deep Cycle 6 Volt Batteries Linked
12 Volt System max 120 Amps Output
Spool of Continuous Fiberglass Rods

1. Installed in a minimum of time and manpower.

2. Two man crew equipped with a 3/4 ton truck and trailer can install the complete lift system in a matter of hours.
Wellbore Description

1. Continuous 1350 Feet of ½ Inch Diameter Fiberglass Rods
2. 1.0625 Inch Diameter Tubing Pump
3. 1.25” OD Poly Lined Tubing
4. 4.5 Inch Casing
5. Fruitland Perforations 1329-1359 Feet
6. Pump Intake Depth 1357.7 Feet
7. Plugged Back TD 1425 Feet
Fluid Level Below Perforations at Pump Intake

Perfs

RTT: 1.874 sec
Jts: 1349.76 ft

Filter Type: High Pass
1350 Ft ½ In Dia Fiberglass Rod

1. Wt Rods Air = 270 Lbs
2. Wt Rods Fluid = 159 Lbs
3. 20 Inch Surface Stroke
4. Spring Constant 77 lbs/In
5. 7.2 Static Stretch
6. 13.9 In. Pump Stroke
7. 556 Lbs Max Fluid Load (0 PIP)
PR 0.087 HP ~ 4.72 SPM ~ 7.9 BPD Pump Disp

Full Pump

0.8 Cups / Stroke
Timer (8 Event Programmable w/ 15 Minutes On)
PR 0.055 HP ~ 4.86 SPM ~ 3.1 BPD Pump Disp

- Pump Off
- Pump Leak ≤ 0.3 Cups / Stroke
Measured Rod Weight within 4 lbs Calculated Wrf

TV Leak Off
Fiberglass Rod’s Stressed to 23% of Allowable

Top Rod Loading As % of the API Modified Goodman Allowable Stress Range for Given Grades

<table>
<thead>
<tr>
<th>Service Factor</th>
<th>C</th>
<th>D</th>
<th>K</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>15.2</td>
<td>11.9</td>
<td>16.1</td>
<td>8.1</td>
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<tr>
<td>0.85</td>
<td>18.0</td>
<td>14.0</td>
<td>19.1</td>
<td>9.5</td>
</tr>
<tr>
<td>0.60</td>
<td>25.9</td>
<td>20.1</td>
<td>27.5</td>
<td>13.5</td>
</tr>
</tbody>
</table>

Beam Loading: 63.6 %

Rod Loading At Top of Tapers As % of the API Modified Goodman Allowable Stress Range

<table>
<thead>
<tr>
<th>Rod Type</th>
<th>Top Taper</th>
<th>Taper 2</th>
<th>Taper 3</th>
<th>Taper 4</th>
<th>Taper 5</th>
<th>Taper 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>FG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diameter</td>
<td>in 0.500</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1.0 23.2

Service Factor

<table>
<thead>
<tr>
<th>0.85</th>
<th>23.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.60</td>
<td>23.2</td>
</tr>
</tbody>
</table>

Rod Stress

Max 4049 psi
Min 667 psi
Net Peak Gearbox Torque 47% of Rating

<table>
<thead>
<tr>
<th>Rating</th>
<th>Peak Balanced</th>
<th>Peak Existing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gearbox</td>
<td>8000</td>
<td>3264.3</td>
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</tbody>
</table>

Counter Balance Change:
- INCREASE For Balance: 464.3 in-lb

Weight Of Counterweights To Be Moved: 148.5 lb

Move Counterweights: OUT 3.1 in from their present location to balance unit

3725 in-lb
# Quick Rod System Design

## Design Inputs

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit</td>
<td>CVConv</td>
</tr>
<tr>
<td>Pump Depth</td>
<td>1,350 ft</td>
</tr>
<tr>
<td>Surface Stroke Length</td>
<td>20 in</td>
</tr>
<tr>
<td>Pump Diameter</td>
<td>1.053 in</td>
</tr>
<tr>
<td>Tubing Size</td>
<td>1.315&quot; (1.7 lb/ft) 1.043&quot; ID</td>
</tr>
<tr>
<td>Anchored Tubing</td>
<td>Yes</td>
</tr>
</tbody>
</table>

## Results

- **Rate (100% Pump eff.)**: 3.42 bbl/day
- **Rate (95% Pump eff.)**: 3.36 bbl/day
- **Rod Taper, %**: 100.0
- **Top Rod Loading**: 24.5%
- **Min API Unit Rating**: 40.75-20
- **Min NEMA D Motor Size**: 0.151 hp
- **Pumped Rod Power**: 0.083 hp
- **TVLoad**: 670 lbs
- **SVLoad**: 156 lbs
- **Max Fiberglass Load**: 494 lbs
- **Min Fiberglass Load**: 118 lbs
- **Max Fiberglass Stress**: 2,050 psi
- **Min Fiberglass Stress**: 603 psi
- **Fiberglass Load**: 0.0%

## Calculate from SPM or Target Rate

- Stroke Rate: 4.72
- Target Rate: 8.00

## Default Settings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Sinker Bar Weight</td>
<td>0 lbs</td>
</tr>
<tr>
<td>Fluid Specific Gravity</td>
<td>1 H2O-1</td>
</tr>
<tr>
<td>Tubing Pressure</td>
<td>32 psi</td>
</tr>
<tr>
<td>Casing Pressure</td>
<td>32 psi</td>
</tr>
</tbody>
</table>

You may enter Pump Intake Pressure directly, or calculate it from Reservoir Pressure and Productivity Index.

## Dynamometer Cards

- **Rod Load (lbs)**: 608
- **Position (in)**: 0-608

## Pump Velocity vs. Position

- **Position (in)**: -6 to 6

## Torque

- **Peak Gear Box Torque**: 3.95 K/in-ft
- **Weight Balance Moment**: 0.95 K/in-ft
- **Counter Balance Effect**: 813 lbs
Comparison of Measured and Designed Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Measured</th>
<th>QRod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight Rods in Fluid - Lbs</td>
<td>155</td>
<td>156</td>
</tr>
<tr>
<td>Minimum Fiberglass Load - Lbs</td>
<td>-13</td>
<td>-118</td>
</tr>
<tr>
<td>Min Polished Rod Load - Lbs</td>
<td>131</td>
<td>133</td>
</tr>
<tr>
<td>Peak Polished Rod Load - Lbs</td>
<td>795</td>
<td>695</td>
</tr>
<tr>
<td>Net Geaxbor Torque - in-Lbs</td>
<td>3264</td>
<td>3000</td>
</tr>
<tr>
<td>Pump Displacement - BPD</td>
<td>7.9</td>
<td>8.42</td>
</tr>
<tr>
<td>Effective Plunger Stroke - in</td>
<td>12.7</td>
<td>13.5</td>
</tr>
<tr>
<td>Polished Rod HP</td>
<td>0.087</td>
<td>0.083</td>
</tr>
</tbody>
</table>

1) Actual Pump Leakage of 37% - Unknown in Design
2) Measured Peak Load 100 Lbs Higher
SolaMotor Limitations for 20, 28, 36 Inch Strokes

1.0625 Diameter Plunger

- PPRL - Lbs
- PRHP
- Min Motor Size - HP

4.72 SPM

Pump Depth

1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000

0 0.05 0.1 0.15 0.2 0.25 0.3 0.35 0.4

1600 1400 1200 1000 800 600 400 200 0

36
28
20
Operational Design Limitations

1. Existing System C-8-12.5-28 4.72 SPM 1.0625 Plunger
   a) Change to the 28” stroke, With Pump Depth about 2300 feet,
   b) Pump displacement of 6 bpd, 0.1 PRHP and 1/3 HP motor OK
   c) Peak Polished rod load 1150+, Gearbox torque 6.33 in-Lbs.
   d) Calculating negative load of -200 lbs at bottom of fiberglass rods.

2. Pump Depth 3000 feet
   a) 36” stroke = 3 BPD and/or 48” stroke = 11 bpd production

3. Pump Depth 4000 feet
   a) 64” inch stroke you can lift 5 BPD
   b) -347 lbs of negative rod load / add 75 feet of 1 ½ “ weight bars

4. Pump Depth 5000 feet with a C-28-32-100 PU
   a) 100” inch stroke can lift 15 BPD w/ 1.1 Motor HP and 0.54 PRHP
   b) 100 ft of 1 ½” Weight Bars w/ Unanchored 2.375” Ploy-Lined Tubing
Observations/Conclusions

1. Reliable operation – 2 years without failure
2. Installed in a minimum of time and manpower.
3. Low Cost Operation
4. Designed Fiberglass & Poly-lined Tubing are corrosion resistant
5. Poly-lined Tubing prevents abrasion wear
6. ½” Diameter Fiberglass Rods are Light Weight
7. Fiberglass Rods can be pulled/ran from Spool without the cost of a Work Over Rig