Longest Stroke and Highest Capacity Reciprocating Sucker Rod Pumping Systems

Dave M. Kennedy, M. Ghareeb and Alvin Woo
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- Long Stroke Skid Mounted Unit Components
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SSi Lift History

- Tundra Process Solutions Acquired Dynapump Assets in 2011/2012 and Rebranded as SSI Lift in 2012 (SSI = Sure Stroke Intelligent)
- Manufacturing Moved from California to Calgary.
- Offices in Houston, Denver, Bakersfield, Dallas, Cairo, Egypt and Bogota, Colombia
- The worldwide number of installations reached +1200 at end of year 2016
- Designed and Built Dedicated Load Tester. All Units Load Tested Prior to Shipment
- Patent on Autostroke Logic issued – Improved PLC Functions - Implemented over 200 Improvements Post Dynapump. Continuous Improvement process
- SO 9001:2015 Certified
Long Stroke Skid Mounted System Overview

- The unit is a computer-controlled hydraulically driven long-stroke high capacity pumping unit.
- It is Ultra Long Stroke, Intelligent and high load capacity Rod Lift System. It comprises of two main components:
  - The pumping unit
  - Power unit
- Available in Seven different models

<table>
<thead>
<tr>
<th>Unit Model</th>
<th>150</th>
<th>250</th>
<th>350</th>
<th>400</th>
<th>400LS</th>
<th>600</th>
<th>800</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroke Length, In</td>
<td>168</td>
<td>240</td>
<td>372</td>
<td>288</td>
<td>336</td>
<td>336</td>
<td>360</td>
</tr>
<tr>
<td>Load, K lb</td>
<td>15</td>
<td>25</td>
<td>35</td>
<td>40</td>
<td>40</td>
<td>60</td>
<td>80</td>
</tr>
</tbody>
</table>

All Units Load Tested Prior to Shipment with in house Designed and Built Dedicated Load Tester
• The pumping unit uses a patented triple cylinder, 2 oil chambers and 1 nitrogen chamber

• The nitrogen chamber offsets 100% of the rod load and 50% of the fluid load

• The 2:1 pulley design doubles the polished rod velocity compared to the cylinder speed

• The cylinder movement and direction of travel is determined by the Main Pump rotation (clockwise / counter clockwise), and speed (RPM) of pump

• The stroke length and reversals are controlled by the settings in the controller, position sensor, and Variable Frequency Drive (VFD). This provide soft turnaround in up and down stroke
Unit Components: Track System
Unit Components: Operator Interface Screen

- Set Speed-Cycle
- Jog Control
- Operations
- Load Graph
- Log In
- General Set Points
- Set Poc Parameters
- Set Load Alarms
- Warnings
- Alarm History
- Set Time Date
- Field Inputs

- Stop Button In
- Directory
- Rod Load: 15256
- CWT PSI: 689
- Position: 3
- Max PSI Up: 1654
- PSI UP: 1589
- SPM: 3.5
- Oil Temp: 106
- Max PSI Down: 1529
- PSI DN: 1456
- Max Load: 16356
- Min Load: 6354
- Stroke Length: 240
- Stroke Ctrl Manual
- Poc Mode Off
- Directory

- Strike Ctrl Mode
- Man Active
- Enc Offset
- Top Stop Position: 250
- Botm Stop Position: 10
- Top Decel Pt: 235
- Botm Decel Pt: 25
- Up Speed: 5
- Down Speed: 4
- Enter New Speed
- Max Auto Height: 260
- Unit Max Height: 250
- Top Decel: 10
- Bottom Decel Pt: 25

- Stop Button In: 01/15/14 07:02
- Directory
- Total Strokes: 410112
- Total Time Powered: 129600 Min
- Total Run Time: 128160 Min
- Reset Counters
Model 350 Unit designed, built, tested and installed in 16 weeks. First installation Dec 2016
Pumping Speed Vs HP

consult SSI engineering if you will required higher SPM when HP is greater then 150 HP
Well Optimization

INTEGRATED PUMP-OFF CONTROL

UP AND DOWN STROKE SPEED IS INDEPENDENT

INSTANTLY CONTROL
STROKE LENGTH
VARIABLE SPEEDS

WHILE THE UNIT IS RUNNING
The System incorporates eight independent speeds for up and down stroking.

Acceleration and deceleration transitions are also independently controlled during rod reversal, which substantially reduces rod stresses.

Slower down stroking reduces the compressive load which can cause buckling of the rods, leading to fewer rod and tubing failures.
Safety and Field Operations

- All adjustments to operations are done on the power skid. No routine operations are required at the pumping unit.

- Braking system is inherent in the system. No mechanical intervention is required.

- Counterbalance is nitrogen, which is easily adjusted very accurately without stopping the unit. No large heavy steel weights required.

- No guy wires required compare to well head mounted hydraulic pumping units.
## Hydraulic Long Stroke Skid Mounted Vs Mechanical Vertical Unit

<table>
<thead>
<tr>
<th></th>
<th>Long Stroke Skid Mounted</th>
<th>Mechanical Vertical</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stroke Lengths</strong></td>
<td>1 – 372”, depending on model, fully variable</td>
<td>Fixed strokes 288”, or 306”, or 366”</td>
</tr>
<tr>
<td><strong>Maximum Polish Rod Load</strong></td>
<td>15,000 lbs to 80,000 lbs</td>
<td>36,000 lbs or 50,000 lbs</td>
</tr>
<tr>
<td><strong>Stroke speed</strong></td>
<td>+0 – 7 spm, fully variable</td>
<td>0.8 – 4.5 spm</td>
</tr>
<tr>
<td><strong>Pumping Speed Stroke Lengths and balance changes</strong></td>
<td>While in operation</td>
<td>Shut down, change drive sheaves, or, install VFD</td>
</tr>
<tr>
<td><strong>Intelligence</strong></td>
<td>Pump off controller built in , alarms and communication. Variable up/down speed,</td>
<td>Separate pump off controller need to add</td>
</tr>
<tr>
<td><strong>Drive system</strong></td>
<td>Hydraulic piston, very few moving parts, low wear</td>
<td>Gear reducers, chain drive, belt carrier</td>
</tr>
<tr>
<td><strong>Counterbalance</strong></td>
<td>Pressure balance with nitrogen, variable by changing pressure</td>
<td>Steel weights, requires pickers/cranes to modify</td>
</tr>
<tr>
<td><strong>Dimension of largest unit</strong></td>
<td>8’ long, 5’ wide, 41.25’ tall, plus hydraulic skid 6’ x 8’ x 8’</td>
<td>23.6’ long, 8.5’ wide, 49.3’ tall</td>
</tr>
<tr>
<td><strong>Base</strong></td>
<td>Pile supported I-beams, approx 8’ x 10’, approximately 3000 lbs</td>
<td>Pile supported concrete pad, 24’ x 8.5’, 29,000lbs</td>
</tr>
<tr>
<td><strong>Shipping weight of largest unit, including counterbalance</strong></td>
<td>22,810 lbs for pumping unit, 8400 lbs for hydraulic drive unit</td>
<td>53,880 lbs for unit, plus 40,000 lbs for counterweights, plus base</td>
</tr>
<tr>
<td><strong>Shipping and set up</strong></td>
<td>One truck trailer, picker, 4 hours on site</td>
<td>More than one truck, large picker/crane</td>
</tr>
</tbody>
</table>
Hydraulic Long Stroke Skid Mounted Vs Conventional Beam Unit
Hydraulic Long Stroke Skid Mounted Vs Beam Unit

<table>
<thead>
<tr>
<th>CONTENTS</th>
<th>Hydraulic Long Stroke Skid Mounted</th>
<th>Beam Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroke Length</td>
<td>longer stroke up 1 to 372&quot;,</td>
<td>Longest stroke length available is 240&quot;.</td>
</tr>
<tr>
<td>Efficiency</td>
<td>Less electrical energy than the conventional beam pumps, overall superior system efficiency is due to the long slow stroke</td>
<td>Less energy efficient.</td>
</tr>
<tr>
<td>Production</td>
<td>At the same number of strokes/ minute, the production is higher due to the longer stroke.</td>
<td>Lower production at the same number of strokes per minute.</td>
</tr>
<tr>
<td>Lifting Capacity</td>
<td>15,000 LB to 80,000 LB depending on model</td>
<td>Maximum capacity is 42,700 LB</td>
</tr>
<tr>
<td>Gassy Wells</td>
<td>Better pump performance in gassy wells</td>
<td>Poor performance on gassy wells. Not able to vary speed without add-on equipment.</td>
</tr>
<tr>
<td>Production VS Well depth</td>
<td>More production due to unit load capacity</td>
<td>Limited production due to unit load capacity</td>
</tr>
<tr>
<td>Physical Dimension</td>
<td>Very compact unit and it is up to 5 times lighter in the weight</td>
<td>Requires a very big area to operate.</td>
</tr>
<tr>
<td>Installation</td>
<td>Can easily install 2 to 3 units per day</td>
<td>Requires heavy machinery and longer time to install</td>
</tr>
<tr>
<td>HSE</td>
<td>All the operation doe form the power back . There are no Heavy equipment and tools required</td>
<td>Having heavy moving components and counterweights could create HSE issues during operation &amp; maintenance.</td>
</tr>
</tbody>
</table>
## Hydraulic Long Stroke Skid Mounted Vs Conventional Beam Unit

<table>
<thead>
<tr>
<th>Well Depth, ft</th>
<th>5000</th>
<th>10000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor</td>
<td>Nema D Motor 100 hp</td>
<td>Nema D Motor 125 hp</td>
</tr>
<tr>
<td>Pumping Unit</td>
<td>L C1280-365-192</td>
<td>SSI 350-372</td>
</tr>
<tr>
<td>Surface Max Load (lbs)</td>
<td>28894</td>
<td>27347</td>
</tr>
<tr>
<td>Surface Min Load (lbs)</td>
<td>4854</td>
<td>5995</td>
</tr>
<tr>
<td>Average Pumping Speed (SPM)</td>
<td>8.18</td>
<td>3.84</td>
</tr>
<tr>
<td>No of daily cycles</td>
<td>11779.2</td>
<td>5529.6</td>
</tr>
<tr>
<td>No of Months to rod failure</td>
<td>55.8</td>
<td>118.9</td>
</tr>
<tr>
<td>Polished Rod Horse Power (hp)</td>
<td>46.36</td>
<td>43.65</td>
</tr>
<tr>
<td>Computed Surface Stroke (in)</td>
<td>193.4</td>
<td>372</td>
</tr>
<tr>
<td>In-balance Max Torque (m in-lbs)</td>
<td>1117.9</td>
<td></td>
</tr>
<tr>
<td>In-balance Gearbox Load</td>
<td>87.3</td>
<td></td>
</tr>
<tr>
<td>Pump Diameter (in)</td>
<td></td>
<td>2.5</td>
</tr>
<tr>
<td>Net Pump Stroke</td>
<td>167.7</td>
<td>357.7</td>
</tr>
<tr>
<td>Net bpd at 100% pump eff.</td>
<td></td>
<td>1000</td>
</tr>
<tr>
<td>Rod Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rod API Size</td>
<td></td>
<td>87</td>
</tr>
<tr>
<td>Rod Loading %</td>
<td></td>
<td>74</td>
</tr>
<tr>
<td>Service Factor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluid Gradient psi/ft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pump intake pressure, psi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>well Head pressure , psi</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Case Study: Production Vs Depth

SSI 350 Production Vs Depth

Assumption
Vertical Well
Pump intake pressure = 10 Psi
Well Head Pressure = 150 Psi Oil API = 30 Deg

Simulation Design by SROD
1. Advantages of long stroke units with reduced SPM will increase MTBF and reduces Well Intervention by:
   1. Lowering peak polish rod load
   2. Reducing the loading by creating higher minimum polish rod load
   3. Decreasing buckling tendencies
   4. Decreasing side loads and drag loads

2. Adjustable upstroke and downstroke speeds allow for more pump fillage.

3. Flexibility of control accelerations and decelerations

4. The Skid Mounted units are designed for ease of balancing the well, changing SPM and/or lengths based on the changing well conditions and this is easily achieved without ever shutting down the well.

5. For high safety and less hazard related to well operation for persons and equipment, the Skid Mounted units are proved to be the best choice. Where all well operation can be done from the power skid
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