Design Your Rod String to Unseat the Pump – But NOT Overload the System

Norman W. Hein, Jr., P. E. (Oil & Gas Optimization Specialists, Ltd.)

Benny J. Williams (Harbison Fischer)

Russell Stevens (Norris)*

Jim Patterson (Norris-O’Bannon)

* Now with Rod Lift Consulting
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The normal rod string design programs consider the loads and resulting stresses to select the smallest rod number and the appropriate rod grade so that the rod string isn’t overloaded when lifting the peak polished rod load.

But what do you do to check that this design is adequate to be able to unseat the pump and retrieve it from the well?

This becomes more difficult when sand, corrosion products, other solids, scale, etc. prohibit pump movement relative to the seating nipple.
Also, while some sucker rod manufacturers may provide the maximum recommended weight indicator pull for their various rod diameters and rod grades, who or where is a check made that the hoisting equipment to pull the rod string and pump doesn’t overload the rig’s hoisting equipment?
6 Basic Loads
Unseating the Pump Loads

Nomenclature:

\[ W_{RBS} = \text{weight of rods in bottom section} \]

\[ B_R = \text{Buoyancy of rods bottom section} \]

\[ B_{eR} = \text{Buoyancy effect of rods} \]

\[ F_{oSN} = \text{Fluid load over seating area} \]

\[ E_L = \text{Effective lift from pump submergence} \]
## Forces to Unseat – Cup Type Hold-down (HD)

<table>
<thead>
<tr>
<th>API Seating Nipple Designation</th>
<th>Force to Unseat w/o pressure (lbf)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Insert Pump (top or bottom HD)</strong></td>
<td></td>
</tr>
<tr>
<td>N11-15</td>
<td>425</td>
</tr>
<tr>
<td>N11-20</td>
<td>500</td>
</tr>
<tr>
<td>N11-25</td>
<td>650</td>
</tr>
<tr>
<td>N11-30</td>
<td>740</td>
</tr>
<tr>
<td><strong>Tubing Pump</strong></td>
<td></td>
</tr>
<tr>
<td>N13-20</td>
<td>500</td>
</tr>
<tr>
<td>N13-25</td>
<td>650</td>
</tr>
<tr>
<td>N13-30</td>
<td>740</td>
</tr>
</tbody>
</table>
# Forces to Unseat – Mechanical Hold-down (HD)

<table>
<thead>
<tr>
<th>API Seating Nipple Designation</th>
<th>Force to Unseat w/o pressure (lbf)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Insert or Tubing Pump – Bottom HD</strong></td>
<td></td>
</tr>
<tr>
<td>N12-15</td>
<td>1,100</td>
</tr>
<tr>
<td>N12-20</td>
<td>1,100</td>
</tr>
<tr>
<td>N12-25</td>
<td>2,000</td>
</tr>
<tr>
<td>N12-30</td>
<td>1,250</td>
</tr>
<tr>
<td><strong>Insert Pump – Top HD</strong></td>
<td></td>
</tr>
<tr>
<td>N14-20</td>
<td>1,000</td>
</tr>
<tr>
<td>N14-25</td>
<td>1,200</td>
</tr>
<tr>
<td>N14-30</td>
<td>2,500</td>
</tr>
</tbody>
</table>
Load to Unseat the Pump with HD

\[ \text{Load}_{TRBS} = \text{WRBS} - \text{BR} - \text{BeR} + \text{FoSN} + \text{HD Unseating Force} \]

Allowable Stress = \( \frac{\text{Load}_{TRBS}}{\text{Area}_{TRBS}} \) \( \leq \) Yield Strength \( \times F \)

Where \( F \) is safety factor; typically 0.8 or 0.9 Min.

<table>
<thead>
<tr>
<th>Rod Grade:</th>
<th>Yield Strength*:</th>
</tr>
</thead>
<tbody>
<tr>
<td>API C &amp; K</td>
<td>60,000 psi</td>
</tr>
<tr>
<td>API D</td>
<td>85,000 psi</td>
</tr>
<tr>
<td>Grade EL</td>
<td>60,000 psi</td>
</tr>
<tr>
<td>Special Grade</td>
<td>115,000 psi</td>
</tr>
</tbody>
</table>

*check w/ rod manufacturer
Max Recommended Weight Indicator Pull (assuming F=0.9)

<table>
<thead>
<tr>
<th>Rod size (in)</th>
<th>Load for Grade C &amp; K</th>
<th>Load for Grade D (54)</th>
<th>Load for Grade D (75, 78, &amp; 90)</th>
<th>Load for Special Grade (96 &amp; 97)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/8</td>
<td>16,560</td>
<td>23,450</td>
<td>24,850</td>
<td>31,750</td>
</tr>
<tr>
<td>3/4</td>
<td>23,850</td>
<td>33,750</td>
<td>35,780</td>
<td>45,725</td>
</tr>
<tr>
<td>7/8</td>
<td>32,475</td>
<td>46,000</td>
<td>48,700</td>
<td>62,200</td>
</tr>
<tr>
<td>1</td>
<td>42,400</td>
<td>60,000</td>
<td>63,625</td>
<td>81,250</td>
</tr>
<tr>
<td>1-1/8</td>
<td>53,675</td>
<td></td>
<td>80,500</td>
<td>102,880</td>
</tr>
<tr>
<td>1-1/4</td>
<td></td>
<td></td>
<td></td>
<td>127,000</td>
</tr>
</tbody>
</table>
Maximum Allowable Stretch (in)

ALLOWABLE STRETCH

\[ \text{MAX LOAD}_{\text{TRBS}} = \text{YIELD STRENGTH} \times A_{RBS} \]

\[ W_{RTS} = W_r \times L \times \frac{\delta_{MS}}{100} + W_r \times L \times \frac{\delta_{US}}{100} \]

\[ B_{RTS} = W_{RTS} \times 0.128 \times G \]

\[ B_{ER} = A_{RBS} \times L \times \left( \frac{100 - \delta_r}{100} \right) \times 0.433 \times G \]

\[ W_{RF} = W_r \times L \times (1 - (0.128 \times G)) \]

DIFFERENTIAL LOAD

\[ \text{DIFFERENTIAL LOAD} = \text{MAX LOAD}_{\text{TRBS}} + W_{RTS} - B_{RTS} + B_{ER} - W_{RF} \]

STRETCH = DIFFERENTIAL LOAD \times \varepsilon_r \times L
Hoisting Equipment Load Capacity

• Rod Elevators:
  – Regular: 15 tons = 30,000 lbf
  – Deep Well: 25 tons = 50,000 lbf

• Sucker Rod Hooks
  – 25 tons = 50,000 lbf
Example: Unseating Stress

• Given: 1.25” plunger, set at 11,000 ft, API 86 D grade rod string, 2.5” tubing, G_{mix} = 1.05
• Find: Stress to unseat pump
• Solution:
  • 1. 86 rod string w/1.25” plunger: 24.3% 1”, 24.5% 7/8”, 51.2% 3/4”; seating nipple ID = 2.280”
  • Wrbs = Wr * L * %R/100 = 1.634 * 11,000* 0.512 = 9202.7 lb
  • Br = Wrbs * 0.128 * G = 9202.7 * 0.128 * 1.05 = 1236.8 lb
  • Ber = Arbs * L * (100-%R)/100 * 0.433 * G = 0.422*11,000*0.488*0.433*1.05 = 1078.7 lb
Ex (cont)

• FoSN = 0.340 * G * (D_{SN})^2 * L = 
  0.340 * 1.05 * (2.28)^2 * 11000 = 20,414.1 lb

• HD unseating = 650 lb

• LOAD_{TRBS} = Wrbs – Br – BeR + FoSN + HD
  = 9202.7 - 1236.8 - 1078.7 + 20414.1 + 650 = 27,951.3 lb

• Stress = LOAD_{TRBS} / Area_{TRBS} = 27951.3 / 0.442 = 63,238.2 psi

• Is stress < YS * F?
  If F = 0.8; YS * 0.8 = 85,000 * 0.8 = 68,000 psi
  If F = 0.9; YS * 0.9 = 85,000 * 0.9 = 76,500 psi
Example: Allowable Stretch

• Given: Same
• Find: Allowable Stretch
• \( \text{Max Load}_{\text{TRBS}} = \text{YS} \times \text{Area rbs} = 85000 \times 0.442 = 37,570 \text{ lb} \)
• \( \text{Wrts} = \text{Wr} \times L \times \% \text{US}/100 + \text{Wr} \times L \times \% \text{MS}/100 = 2.9 \times 11000 \times 0.243 + 2.2 \times 11000 \times 0.245 = 7751.7 + 13734.6 = 21,486.3 \text{ lb} \)
• \( \text{Brts} = \text{Wrts} \times 0.128 \times G = 21486.3 \times 0.128 \times 1.05 = 2,887.8 \text{ lb} \)
• \( \text{Ber} = \text{Arbs} \times L \times (100-\%R)/100 \times 0.433 \times G = 0.442 \times 11000 \times 0.488 \times 0.433 \times 1.05 = 1078.7 \text{ lb} \)
• Total Allowable Load = \( \text{Max Load}_{\text{TRBS}} + \text{Wrts} - \text{Brts} + \text{Ber} = 44200.0 + 21486.3 - 2887.8 + 1078.7 = 63,877.2 \text{ lb} \)
• $W_{rf} = W_{rbs} \times L \times (1-0.128 \times G) = 2.087 \times 11000 \times 0.866 = 19,880.8 \text{ lb}$

• Differential Load = Total Allowable Load – $W_{rf} = 63,877.2 - 19880.8 = 43,996.4 \text{ lb}$

• Allowable Stretch (once all stretch taken out by pulling up to standing valve load) = Differential Load $\times E_r \times L = 43,996.4 \times 0.732 \times 10^{-6} \times 11000 = 354.3 \text{ inches} = 29.5 \text{ feet}$
What is rod string overloaded?

• Calculate amount of overload stress, convert to fluid load height (EL) then load the backside (or shut down the well and wait for annulus to fill)
• OR, if bottom hold-down and installed Pressure Actuated Tubing Drain, pressure up, burst rupture disk and let liquid drain from tubing
• OR, rig crew has to do a wet pulling job.
We are now offering a tubing drain that is integrated into a bottom hold-down insert pump. A bushing similar to our 80 series has a small rupture disc installed on the OD. The tubing drain bushing is used between the hold-down and the standing valve. This product is specifically targeted towards wells that produce a lot of particulates that could cause problems when pulling the pump. If the pump sticks, bursting the rupture disc may wash away some of the particulates allowing the pump to be pulled without having to pull tubing. Since the rupture disc is on the pump it can be replaced without pulling the tubing. It also allows a tubing drain to be added without having to pull tubing.
Conclusions & Recommendations

• A “new” method has been developed to calculate the load/stress necessary to unseat a SRL pump

• A “new” method has been developed to calculate the amount of allowable stretch necessary to unseat the pump w/o overloading the rod string or check rod manufacturer max weight indicator pull data

• If unseating stress is greater than allowable, a calculation has been provided for the minimum required fluid level to fill annulus

• If know a well has sticking pump, should consider installing a tubing drain

• Need to check if the hoisting equipment will be overloaded
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