Two-Piece Plunger Fall Velocities and Practical Application in the Field

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Introduction

- Previously 2-piece plunger fall velocity has not been measured using Echometer plunger tracking techniques.
- Now can recognize 2-piece collars echoes by combining:
  - High frequency data sampling rate (480 HZ)
  - New TAM software improves plunger tracking capabilities and visualization.
- Observations: plunger fall against flow, plunger fall against no flow, fall velocity when sleeve catches the ball prior to reaching the Bumper Spring Assembly, BSA, and rise velocity.
- Field examples will be discussed: 1) broken plungers, 2) damaged BSAs and 3) loaded wells due to plunger falling off the rod.
2-piece plunger tracking
TWO PIECE

• Sleeve
• Ball
• Bumper Spring Assembly

MECHANICAL COMPONENTS

• LUBRICATOR
• SURFACE SPRINGS
• ANVIL
• SHIFTING ROD
Data Collection – for Fast Falling Plunger

30 HZ “Noise” @ 480 HZ Becomes Data

- 30 HZ
- 480 HZ

1.0 min

0.1 min

Noise

Collars
Zoom in to See Sleeve Fall Fast (480 HZ)

Elapsed Time of 8.0 Seconds

Can Determine 3189 ft/min Sleeve Fall Velocity
Acquired Data is Now Easier to See

Limited 800x600 Size

Limited by Screen Size
2-Piece “Normal” Plunger Cycle

With Afterflow

Plunger Falling

psi (g)

Casing Pressure
Tubing Pressure
Tubing Acoustic

Time - minutes
Two Piece Plunger Cycle

Source: DR. James F. Lea

1. Ball and cylinder rise together.
2. Cylinder slides over rod - ball falls.
3. Ball goes to bottom.
5. Ball & cylinder rise again.

Possible liquid load

Gas
7 Sleeve at Surface
8-9 During 20 sec Shut-in to release sleeve of rod

<table>
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<tr>
<th>#</th>
<th>DESCRIPTION</th>
<th>TIME</th>
<th>TUBING psi (g)</th>
<th>CASING psi (g)</th>
<th>ACOUSTIC</th>
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<tr>
<td>7</td>
<td>Afterflow Holds Sleeve on Rod at Surface - Ball Fall</td>
<td>2024.95</td>
<td>419.0</td>
<td>553.3</td>
<td>-0.006512254</td>
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<tr>
<td>8</td>
<td>Shutin to release Sleeve from Rod</td>
<td>2373.31</td>
<td>418.2</td>
<td>551.3</td>
<td>0.029095411</td>
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<td>9</td>
<td>Motor Valve Opens</td>
<td>2392.62</td>
<td>458.0</td>
<td>551.0</td>
<td>0.000158846</td>
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<tr>
<td>10</td>
<td>Ball and Sleeve Seal Lifting Liquid</td>
<td>3635.23</td>
<td>410.0</td>
<td>549.4</td>
<td>-0.001422763</td>
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<td>11</td>
<td>Sleeve Slides Over Rod - Ball Falls</td>
<td>3712.99</td>
<td>500.8</td>
<td>547.6</td>
<td>0.001041293</td>
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</table>

Feb. 20 - 22, 2017
2017 Gas Well Deliquification Workshop
Denver, Colorado
Plunger Cycle – Shut-in After Arrival

Sleeve Falls

Ball+Sleeve Fall

Sleeve catches the ball

Tubing:
IG IG1083

Casing:
PT 15591

PT 15288

Elapsed Time

End Time: 01:16:18 PM
Duration: 01:06:23
Sample Rate: 480 hz

Selection: 13.005 min

007972 mV
286.0 psi (g)

283.5 psi (g)

Feb. 20 - 22, 2017

2017 Gas Well Deliquification Workshop
Denver, Colorado

12
@ 50\textsuperscript{th} Joint
Sleeve caught the ball

<table>
<thead>
<tr>
<th>#</th>
<th>Time (clock)</th>
<th>Velocity (ft/min)</th>
<th>Depth (ft)</th>
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<td>12:37:57 PM</td>
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<td>1526.22</td>
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<td>C50</td>
<td>12:37:58 PM</td>
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<td>1557.37</td>
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<td>C51</td>
<td>12:38:01 PM</td>
<td>-791.74</td>
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<td>C52</td>
<td>12:38:03 PM</td>
<td>-888.18</td>
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</table>

Average Plunger Vel. (gas): -1215.49 ft/min  
Average Jts/min (gas): 39.024

Sleeve Only

Sleeve+Ball

Plunger Hits Liquid: 4982 ft

Bottom of T
Sleeve/Ball Arrive at Surface

19.5 min Ball and Sleeve Arrive at Surface
Shifting Rod Knocks Ball off Sleeve.
Ball Falls and Sleeve held at Surface.

Ball Seated in Sleeve
Reaches Max Depth of
3677 Ft
Sleeve Released from Shifting Rod

20.467 min ~ Increasing Tubing Pressure Releases Sleeve from Shifting Rod

Sleeve Only Falls at an Average 2242 Ft/Min
Sleeve Catches Ball in 1782 Feet

- Ball Only Falls at $\frac{1782}{(21.333 - 19.5)}$ an Average 972 Ft/Min
- Ball Seated in Sleeve Falls at an Average 275 Ft/Min
- 21.333 min ~ Sleeve Catches Ball at Depth of 1782 ft from Surface
Before Dropping Sleeve Must Know Ball Fall Velocity – Wait Until Ball Falls

Gas(0.65) - Various $V_{\text{fall}}$ rates for Ball

972 Ft/Min
Two Piece Plunger Can Fall Fast (480 HZ)

Elapsed Time of 1.617 Minutes

61.55 Min Sleeve On Bottom

59.933 Min Sleeve Off Shifting Rod
Sleeve Averaging -3189 Ft/Min Fall

Define Cycle  Cycle Limits  Plunger Fall  Gas Properties

Selection: 8.00 sec

<table>
<thead>
<tr>
<th>#</th>
<th>Time (min)</th>
<th>Velocity (ft/min)</th>
<th>Depth (ft)</th>
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<tbody>
<tr>
<td>C1</td>
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<td>-1407.63</td>
<td>32.31</td>
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<tr>
<td>C2</td>
<td>59.982</td>
<td>-2308.80</td>
<td>64.61</td>
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Average Plunger Vel. (gas): -3189.33 ft/min  Average Jts/min (gas): 98.719
Average Plunger Vel. (Liq.): -0.00 ft/min   Average Jts/min (Liq.): 0.000
Count Collars to 3133 Ft
Damaged plungers
Conclusion

• Field data shows 2-piece plunger fall velocity can be measured using Echometer plunger tracking techniques
• Need to use High Speed Data Acquisition (480 HZ)
• Software improved visualization displays 100 echoes per minute at reasonable scale to determine plunger velocity
• 2-piece plunger
  – Fell 2200 ft/min against flow,
  – Fell against 3600 ft/min no flow
  – Sleeve catches the ball prior to reaching the BSA
• Common problems are: 1) broken plungers, 2) damaged BSAs and 3) loaded wells due to sleeve falling off rod
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