Liquid Level Depth Determination in Unconventional Wells Assisted with Wellbore Diagram

Ryan Craig
O. Lynn Rowlan
Introduction

- Unconventional Wells have complicated well bores
- Distance to the liquid level provides beneficial information with during operation of each types of producing method.
- A New technology of displaying the acoustic trace together with the wellbore diagram provides:
  - Improved analysis method for determining accurate distance to the liquid level
  - Troubleshooting Tool
- On the acoustic trace the direction of the reflected echo indicates a well bore cross-sectional area enlargement or reduction.
- Overlaying the acoustic trace on the top of a wellbore schematic allows for a quick visual confirmation of each echo belonging to a change in the cross-section of the well
- Display of Downhole Wellbore Markers and measured depth along with the round trip time travel of acoustic trace make very accurate depth determination possible
Acquire a Quality Fluid Level Shot

- Requires stabilized conditions for accurate BHP.
- Determination of Liquid Level Depth: obtain a clear indication fluid level echo.
- Correct average tubing joint length: required to calculate distance to fluid level and accurate acoustic velocity.
- Wellbore deviation survey: required to compute pressure in wellbore and at pump intake.
- Measurement of casing pressure: required for correct calculation of pump intake pressure.
- Measurement of casing pressure change vs. time: required to calculate annular gas flow rate and annulus liquid fraction.
- Tubing, Casing diameters: required for calculation of annular gas rate.
- Oil, water and annular gas densities: required for calculation of pressure gradients.
- Measurements should be repeated whenever excessive acoustic noise is present and fluid level echo is not clearly identifiable (always acquire 2 shots).
1. On the acoustic trace the direction of the reflected echo kick indicates enlargements and reductions.
2. For an Explosion shot reduction in the cross sectional area are displayed as downward kicks.
3. Wellbore decreases displayed as a **down kick**:
   - Liners tops, tubing anchors, paraffin/scale deposits, blockages, the liquid level.
4. Wellbore increase displayed as **upward kick**:
   - Hole in tubing, perforations, open hole, sliding sleeves, parted casing, parted tubing, end of tubing.
5. Implosion created acoustic trace, then the echoes will be reversed from explosion pulse echoes.
6. Select pulse type; then inverted implosion and explosion acoustic traces show same direction of kick.
What is an Acoustic Fluid Level

- Created by a pressure change in a gas or liquid. – *Bang the Shot is Fired*
- Propagate through the gas at a speed of sound called *Acoustic Velocity*.
- Portion of *Traveling Wave* or sound/pressure wave is reflected by solids or liquids in the path of the wave.
- *Echoes* created inside a tube when reflected by changes in diameter of tube.
- The greater the change in diameter the larger is the amplitude of the reflected wave. (More Energy Reflected need *Increased Charge Pressure*)
Direction Kick Identifies Downhole Echo

**Initial Acoustic Pulse** – explosion of compressed gas into the casing annulus forms compression traveling wave.

**Up Kick** – INCREASE in the annular cross-sectional area displayed as an upward kick on the acoustic trace.

**Down Kick** – DECREASE in the annular cross-sectional area displayed as an downward kick on the acoustic trace.

Shot

Distance To Liquid 1887 ft MD

Perforation Depth: 1808 ft

1887 ft MD

Perforation Depth: 1369 ft

Perforation Depth: 1531 ft

Perforation Depth: 1808 ft

Perforation Depth: 1889 ft

End Of Tubing

---

Feb. 4-7, 2018

2018 Artificial Lift Strategies for Unconventional Wells Workshop

Oklahoma City, OK
Location of the Liquid Level Can Be Used to Determine Well Performance

- Liquid Level is at Pump Intake
- Only Casing Pressure Acting on Formation, No Pressure from Liquid
Wellbore Overlay for Gas-Lift Well
Downhole Marker Method Often Used on Gaslift Wells

Distance To Liquid 7264 ft MD

1. Gas Lift Valve
   Depth: 5707 ft

2. Gas Lift Valve
   Depth: 6233 ft

3. Gas Lift Valve
   Depth: 6791 ft

Gas Lift Valve
Depth: 6791 ft
Mandrel Design Determines Direction of Kick

- Shot Down Tubing Displays Upkick at Mandrel
- Increase in area = Upkick
- Shot Down Casing Displays Downkick at Mandrel
- Decrease in area = Downkick
Gas Flow Up Tubing and Casing Valve is Closed:

1. Fluid Level Should be at End of Tubing
2. Wellbore Description
   - Important
   - Distance Determined
   - Identify Marker
   - Count Collars
   - Gas Composition

---

In Gas Well Casing Fluid Level At EOT

**Acoustic Velocity**
- 1273.8 ft/s
- **SG = 0.72**

**Marker:**
- Top Perf 10364 Ft.
- 16.281 Sec.

**Liquid Level**
- 10536 Ft.
- 16.548 Sec.
Sucker Rod Lift Multiple Echoes Due to Liner Makes LL Selection Difficult

Distance To Liquid: 4457 ft MD

RTT (sec) 7.457
#JTS 137.60
AV 1195 ft/s

Fluid Above Pump 12 ft TVD
Equivalent Gas Free Above Pump 7 ft TVD

NOT Top Perf
NOT Liquid Level

Tubing Anchor
Depth: 4017 ft

Liner
Depth: 4152 ft

End Of Tubing
Depth: 4470 ft

Perforation
Depth: 4907 ft
Which Down Kick is the Liquid Level

Distance To Liquid: 5021 ft MD

End Of Tubing Depth: 4889 ft

1. Tubing Anchor
   Depth: 4144 ft

2. Liner
   Depth: 4384 ft

3. Gas Separator
   Depth: 4819 ft

4. End Of Tubing
   Depth: 4889 ft
Look for Liner Down-Down-Up Kicks
Common to use acoustic liquid level instrument to shoot distance to the liquid level in the casing annulus

Much-lesser-known is to shoot fluid levels inside the tubing (instead of just inside the casing annulus)

Use Up Kick to Find Depth to the Hole
1. Hole in Tubing Shown as **Up Kick** when **Pump Off** and Time has Passed to Allow Liquid to Drain out of Tubing.

2. Hole in Tubing Shown as **Down Kick** when **Pumping** Liquid Out Tubing Hole into Casing Annulus
Pump Card Abnormal Loads Due to Lifting Liquid out a Hole and Not Lifting to the Surface

Fo = 1508 Lbs if Lifted to Hole @ 4052’ From 6583’ Fluid Level
Use less pressure differential in gas gun to shoot the liquid level and see echoes near the surface OR apply low pass filter to remove noise.

Feb. 4-7, 2018
Comparing Hole in Tubing Echo Overlay of Low Pass Filter Casing Shot to Raw Tubing Shot

Distance to the Hole is 263 feet
Is Up Kick on Tubing Shot From Hole?

1” to 7/8” Taper Increases Tubing Internal Area

- Rod Type: Top Taper KD, Taper 2 D, Taper 3 KD, Taper 4 SB
- Length: Top Taper 2000.0, Taper 2 2375.0, Taper 3 2900.0, Taper 4 250.0
- Diameter: Top Taper 1.000, Taper 2 0.875, Taper 3 0.750, Taper 4 1.500
Conclusion

- New technology displaying the acoustic trace together with the wellbore diagram provides an improved analysis.
- On the acoustic trace use the direction of the reflected echo to identify each well bore cross-sectional area enlargement or reduction.
- Need to use an accurate and representative wellbore schematic!
- If using Collar Count, make sure the Average Joint Length is correct.
- The deeper the Marker, the more accurate the liquid level depth.
- If there is a question between using the Collar Count or DHM, use whichever is closest to the liquid level.
Copyright

Rights to this presentation are owned by the company(ies) and/or author(s) listed on the title page. By submitting this presentation to the Artificial Lift Strategies for Unconventional Wells Workshop, they grant to the Workshop, the Artificial Lift Research and Development Council (ALRDC), and the Southwestern Petroleum Short Course (SWPSC), rights to:

- Display the presentation at the Workshop.
- Place it on the www.alrdc.com web site, with access to the site to be as directed by the Workshop Steering Committee.
- Place it on a CD for distribution and/or sale as directed by the Workshop Steering Committee.

Other use of this presentation is prohibited without the expressed written permission of the author(s). The owner company(ies) and/or author(s) may publish this material in other journals or magazines if they refer to the Artificial Lift Strategies for Unconventional Wells Workshop where it was first presented.
The following disclaimer shall be included as the last page of a Technical Presentation or Continuing Education Course. A similar disclaimer is included on the front page of the Artificial Lift Strategies for Unconventional Wells Web Site.

The Artificial Lift Research and Development Council and its officers and trustees, and the Artificial Lift Strategies for Unconventional Wells Steering Committee members, and their supporting organizations and companies (here-in-after referred to as the Sponsoring Organizations), and the author(s) of this Technical Presentation or Continuing Education Training Course and their company(ies), provide this presentation and/or training material at the Artificial Lift Strategies for Unconventional Wells Workshop "as is" without any warranty of any kind, express or implied, as to the accuracy of the information or the products or services referred to by any presenter (in so far as such warranties may be excluded under any relevant law) and these members and their companies will not be liable for unlawful actions and any losses or damage that may result from use of any presentation as a consequence of any inaccuracies in, or any omission from, the information which therein may be contained.

The views, opinions, and conclusions expressed in these presentations and/or training materials are those of the author and not necessarily those of the Sponsoring Organizations. The author is solely responsible for the content of the materials.

The Sponsoring Organizations cannot and do not warrant the accuracy of these documents beyond the source documents, although we do make every attempt to work from authoritative sources. The Sponsoring Organizations provide these presentations and/or training materials as a service. The Sponsoring Organizations make no representations or warranties, express or implied, with respect to the presentations and/or training materials, or any part thereof, including any warrantees of title, non-infringement of copyright or patent rights of others, merchantability, or fitness or suitability for any purpose.