Acoustic Troubleshooting of Coal Bed Methane Wells

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Introduction

- Distance to the liquid level provides beneficial information with respect to the pump and the gas producing zones in coal bed methane wells.

- Effectiveness of the artificial lift system can be evaluated in dewatering the coal beds.

- Liquid levels can be used to help determine whether a problem is occurring in the wellbore or in the equipment.

- Quick surface measurement determines if:
  - Liquid is above the pump
  - Reducing production by applying additional pressure on the formation
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 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 a 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 a downward kick on the acoustic trace.
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

Determine LL Depth by Counting Collars

1. Choose collar region

2. Adjust collar markers

- Auto Collar Selection
- Manually Adjust Collars
- Scale: + -

Interval AV: 1418 ft/s
Average AV: 1428 ft/s
Interval Jts/Sec: 21.74
Average Jts/Sec: 21.89
Liquid Level: 1879 ft
Gas Gravity: 0.60


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Determine LL Depth with Known Markers

1. Select Marker to Move
   - Perforation Depth: 1368 ft
   - Perforation Depth: 1531 ft
   - Perforation Depth: 1808 ft
   - End Of Tubing Depth: 1879 ft
   - Casir Depth: 1899 ft

2. Align Marker With Shot
   - Shot

3. Refine Marker Position @ 2.141 sec
   - Acoustic Velocity: 1430 ft/s
   - Liquid Level: 1881 ft
   - Gas Gravity: 0.60

4. Verify Results
   - Echo Zoom
   - Zoom All
   - Window Size: + -
Determine Acoustic Velocity in Range

Acoustic Velocity options:

- Manually entered
- Calculated based on SG of gas
- Calculated based on compositional analysis

(Manual entered can be used for approximations or where velocity already determined by collars or downhole marker in other shots)

Depends on:

- Gas gravity / composition
- Average Temperature and Pressure

(automatically calculated from acoustic velocity from a shot)
If Depth to Liquid Level NOT Obvious
Then Move the Liquid Level

- Acoustic Traces do not repeat
- Multiple Downhole Reflections
- Liquid Level Below Liquid Entry
- Liquid Level Below Partial Annulus Obstruction

- RAISED by shutting down Producing Well.
- DEPRESSED by increasing casing pressure, if casing gas is produced.
Proved Liquid Level by Moving It with Increased Casing Pressure

Salt Water Gradient 0.50 psi/ft = 2 ft change / 1 psi change
Condensate Gradient 0.333 psi/ft = 3 ft change / 1 psi change
Gassy Loaded Gradient >0.1 psi/ft = 10-15 ft change / 1 psi change

Shot 1:
02:16:23 PM
Casing 3.5 Psi

Shot 2:
02:24:48 PM
Casing 7.9 Psi

change = 4.4 psi
change ~ 8.8 feet
Increasing Casing Pressure by 4.4 Psi Should Depress Gassy Fluid > 8.8 Feet

<table>
<thead>
<tr>
<th>Shot 1: 02:16:23 PM</th>
<th>Distance To Liquid</th>
<th>392 ft</th>
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<tbody>
<tr>
<td>Fluid Above Pump</td>
<td>52 ft</td>
<td></td>
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<tr>
<td>Equivalent</td>
<td>48 ft</td>
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<tr>
<td>Gas Free Above Pump</td>
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<table>
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<th>Distance To Liquid</th>
<th>407 ft</th>
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<tbody>
<tr>
<td>Fluid Above Pump</td>
<td>37 ft</td>
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<tr>
<td>Equivalent</td>
<td>35 ft</td>
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<tr>
<td>Gas Free Above Pump</td>
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</tbody>
</table>

RTTT (sec) 0.567  #JTS 12.98  AV 1422 ft/s  Jts/sec 22.66

Perforation Depth: 341 ft

15 Feet
Increase Echo Size Using More Charge Pressure and/or Large Volume Chamber

Volume Chamber
12.5 VS 36 CU IN.

Pressure Charge
100 Psi
350 Psi
900 Psi

Perforation Depth: 5080 ft
Liquid Level Echo Not Visible with Low Charge Pressure or Small Gas Volume

-1.5 Psig Casing Pressure
Distance To Liquid 911 ft

RTIT (sec) 1.304  #JTS 29.42  AV 1392 ft/s  Jts/sec 22.46

Fluid Above Pump 1 ft
Equivalent Gas Free Above Pump 1 ft

500 psi
300 psi
900 psi

Big Volume Chamber - 900 psi

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To See LL Apply High Pass Filter
Emphasizes Perfs and Flattens Trace
To See LL Apply Low Pass Filter
Removes High Frequency Noise Spikes

Apply Low Pass Filter
General Fluid Level Comments

1) Acoustic fluid level measurements are easily performed in producing or shut in wells

2) Recommended practice is to always acquire at least two (2) acoustic fluid level records when connected to a well

3) When shooting down the tubing or casing, EUE collar Echoes can normally be detected

4) Using an echo from a known down hole marker near the fluid level is usually the most accurate method to determine depth.

5) Using gas composition is often the least accurate depth determination analysis method
For Accurate LL Depth Determination:

1. Use an accurate and representative wellbore schematic!
2. The deeper the Marker, the more accurate the liquid level depth
3. Verify correct reflection on the acoustic trace is selected to represent the perforation selected as the Downhole Marker.
4. At 1400 ft/sec acoustic velocity, a 1/10 second difference in marker selection will make a 70 ft difference
5. As a quality check, always verify the calculated acoustic velocity is within the known range.
6. If there is a question between using the Collar Count or DHM, use whichever is closest to the liquid level.
7. If using Collar Count, make sure the Average Joint Length is correct.
8. Do not shoot through a needle valve, always connect gun close to casing, and do not shoot through Chemical Pots.
Conclusions

• Shallow wells can be difficult to determine accurate distances to liquid levels.

• Perforations, open hole, liner and quick echoes from the liquid level create many echoes on the acoustic trace.

• For accurate analysis the echo from the liquid level echo must be identified.

• Special filtering techniques can be applied to emphasize the liquid level echo.

• LL acquired on coal bed methane wells provide a low cost, direct method to observe the well; benefiting the operator through knowledge of the well’s producing conditions.
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