Direction of Kick on Acoustic Traces

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http://www.echometer.com/Software/Total-Asset-Monitor
Introduction

• New technology 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
• Downhole Marker Method - Display of the acoustic trace with round trip time travel to each anomaly echo associated to the measured depth to the anomaly
• Distance to the liquid level provides beneficial information with respect to the pump and complicated well bores.
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*)
Echoes in Well

1. Changes in cross-sectional area cause sound waves to reflect back to microphone.

2. Initial kick from gun blast.

3. Series of small kicks indicate the tubing collars.

4. Low frequency kick from Liquid level recorded.

5. Recorded signal trace corresponds to the pulse traveling from the gun's microphone to the liquid level and then back to the surface.
Data collected on a shut-in gas well JW-131 using Compact Gas Gun.

Compact Gas Gun charged to 400 Psig to generate the compression acoustic pulse.

Well’s casing pressure of 205 Psig used to generate implosion pulse.

**Explosion Vs Implosion Example**

- **400 Psig Explosion**
  - Pulse Type: Explosion
  - RTTT (sec): 2.505

- **205 Psig Implosion**
  - Pulse Type: Implosion
  - RTTT (sec): 2.507
  - Downhole Marker: PFL_Imp_Exp

**Graphs:**
- Upper graph: 400 Psig Explosion
- Lower graph: 205 Psig Implosion
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).
Direction of Kick of the Acoustic Signal

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 an **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**: Explosion OR Implosion then wellbore decreases will be displayed as downward kicks and increases as upward kicks
Echoes from Diameter (cross section area) Changes

Restrictions inside tubing

Enlargements in annulus

Acoustic trace

Time

0 ft 3000 ft 5000 ft
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.

Distance To Liquid: 1887 ft MD

Perforation Depth: 1808 ft

**Downhole Marker:** PFL_DHM_CoalBedPerfs
Only Liquid Level Can Move

Observe Downhole Anomalies

Perfs:
1369. –1371.
1530.5-33.5
1807.5-09.5

Casing Wt Change from 26# to 38# at 5913'
ID change from 6.276” to 5.92”

Downhole Marker: PFL_DHLM_CasingWtChange

Shot
Well bore goes from 26# casing to 38# casing at 5913'
Wt change from 6.276 to 5.92
Depth: 5913 ft
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
Downhole Marker using Perforations VS. Automatic Collar Counting

Downhole Marker: PFL_RotaFlex

Distance To Liquid: 8005 ft MD

Distance To Liquid: 7989 ft MD
Echoes due to Wellbore Area Changes

Enlargements cause inversion of pulse polarity

Hole Enlargement

Liquid Flow Through Perfs

Open Perfs
Repeat SSSV echoes can be seen after each Anomaly echo and should be ignored.
Wellbore Overlay for Gas-Lift Well

Downhole Marker Method Often Used on Gaslift Wells

Distance To Liquid: 7264 ft MD

Gas Lift Valve
Depth: 5707 ft

Gas Lift Valve
Depth: 6233 ft

Gas Lift Valve
Depth: 6791 ft

Gas Lift Valve
Depth: 7349 ft
Multiple Echoes Due to Liner Makes LL Selection Difficult

Distance To Liquid: 4457 ft MD

RTTT (sec): 7.457

#JTS: 137.60

AV: 1195 ft/s

Jts/sec: 18.45

Fluid Above Pump: 12 ft TVD

Equivalent Gas Free Above Pump: 7 ft TVD

Dodd 900H

NOT Top Perf

NOT Liquid Level

Tubing Anchor
Depth: 4017 ft

Downhole Marker: PFL_TAC Liner_Separator
Which Down Kick is the Liquid Level

Distance To Liquid: 5021 ft MD

End Of Tubing Depth: 4889 ft

Downhole Marker: PFL_TAC Liner_Separator

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

Downhole Marker: PFL_Liner_ManyRepeats
Too High Charge Pressure

Proper Charge Pressure

Downhole Marker: PFL_Very_High

RTTT (sec) 0.104

Shallow Liquid Level
Must Manually Select High Liquid Level

1st Second of Acoustic Data Is ignored in Automatic Processing for Liquid Level Detection

Operator Must Manually Moved LL marker to 0.628 Seconds

Auto Pick 1st Repeat

Downhole Marker: PFL_High
Common to use acoustic liquid level instrument to shoot distance to the liquid level in the casing annulus

Much-less-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

Downhole Marker: Plunger_Hole_4325
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

“TROUBLESHOOT ROD PUMPED WELLS USING TUBING FLUID LEVEL SHOTS”, J. Sparks, L. Rowlan, SWPSC 2014

**Downhole Marker: Leak Tubing Hole**
Pump Card Abnormal Loads Due to Lifting Liquid out a Hole and Not Lifting to the Surface

$F_o = 1508$ Lbs if Lifted to Hole @ 4052’ From 6583’ Fluid Level

$F_o = 10.57$ Klb

$F_o$ From Fluid Level ($F_o$ FL) = 3.77 Klb

$F_o$ Max = 3.93 Klb

$EPT = 78.60$ in
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.
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

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<th>Rod Type</th>
<th>Top Taper</th>
<th>Taper 2</th>
<th>Taper 3</th>
<th>Taper 4</th>
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Conclusion

- Displaying the acoustic trace together with the wellbore diagram provides an improved ability for 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.
Recommendation

Handbook for those that would like to learn more, please click on following link:


to “Acoustic Fluid Level Measurements in Oil and Gas Wells Handbook Paperback – January 1, 2017” by Dr. A. L. Podio (Author), Jim McCoy (Author)

A comprehensive technical handbook that discusses the importance, application, and interpretation of acoustic fluid level measurements for all types of wells and measurement instrumentation, ranging from strip charts to digital sensors.