TROUBLESHOOT ROD PUMPED WELLS USING TUBING FLUID LEVEL SHOTS

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1. Practice of shooting fluid levels has become a well-known mainstay to daily operations

2. Common to use acoustic liquid level instrument to shoot distance to the liquid level in the casing annulus

3. Determine if a well is producing the maximum fluid potentially available from the formation

4. Determine if the current artificial lift method needs to be modified to increase production

5. Much-lesser-known is to shoot inside the tubing.

6. Valuable trouble-shooting technique to shoot down the tubing on wells that have either stopped producing, or production rate has drastically decreased.
Generate Blast to Create Traveling Wave

Acoustic Wave Travels at Speed of Sound

Echoes from well bore diameter change recorded at Round Trip Travel Time

- Reduction seen as a down-kick (Liquid Level)
- Increase is seen as an up-kick (Hole in Tubing)
- Liquid Level, LL, gives large kick and lets almost no energy past
Direction of Kick of the Acoustic Signal

1. Reflected echo 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. Software allows the selection of implosion pulse type so trace is inverted; then implosion and explosion acoustic traces on the same well appear identical.
1. Upon arrival a well is normally turned off, if the well is suspected of no pump action or no production.

2. Acquire two (2) fluid level shots down the casing and verify acoustic traces appear the same on both shots.

3. Acquire two (2) fluid level shots down the tubing and verify acoustic traces appear the same on both shots.

4. Since the shut-in well is normally quiet the casing tubing collar echoes are normally very clear.

5. Remember that inside the tubing of a rod-pumped well, the presence of rod couplings skews the analysis and that’s why it’s necessary to use the acoustic velocity obtained in the casing fluid level analysis.
Potential Results from Analysis

1. Whether or not the well has a hole in the tubing.

2. If the well has kicked
   a. Excessive gas flow has unloaded the tubing liquids
   b. Backpressure adjustment is required to apply more tubing pressure.

3. Is gas flowing up the tubing? Determined by $\frac{dP}{dT}$ greater than 0 from the pressure buildup test.

4. % liquid in the tubing, determines the effectiveness of the downhole gas separation equipment.

5. Tubing fluid level shots at regular intervals can show the operator if a well is truly “pumping up.”

6. Too much paraffin makes shooting difficult – so beware.
Liquid Level Depth (LL) of 4458 feet is determined by counting as many collars as possible and using the average acoustic velocity of the collars counted to determine the distance to the liquid level.

Collars count depth (C) is noted on the acoustic signal.

For Accuracy Verify 4207 ft Distance to Tubing Anchor

Sept. 17 - 20, 2013
2014 Sucker Rod Pumping Workshop
Distance down tubing is determined by using the average acoustic velocity obtained from the casing shot, because inside the tubing the echoes from couplings are spaced at the length of the sucker rods.
Liquid Level Depth (LL) at 3678 feet is above tubing anchor and perfs. High hole in tubing is suspected, but no obvious up kick seen on trace.
Remove Collar Noise Collars to See HIT

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.
Casing Acoustic Velocity Determined to be 973 ft/sec by Counting Tubing Collars Near Surface

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Casing acoustic velocity determined to be 973 ft/sec

Tubing Collars Frequency in Casing of 14.96 Jts/second at 32.15 ft/joint

Rod Couplings Frequency in Tubing of 19.46 Jts/second at 25.0 ft/joint
Comparing Tubing Hole Up Kick Echo by Overlay of Low Pass Filtered Casing Shot to Raw Tubing Shot

Distance to the Tubing Hole is 263 feet
Find the Tubing Hole

- Shooting fluid levels down can show if there is a hole in the tubing.
- Begin by shooting a fluid level down the casing.
- Connected to the tubing valve and use the same procedure as shooting a fluid level inside the casing.
- Shooting inside the tubing usually requires 50 to 65% less charge pressure into the gas gun than is normal for the casing shot.
- Using the acoustic velocity determined from analyzing the casing shot generally is the easiest and most accurate method for determining distance down the tubing.
- Rod on tubing wear often creates a hole in the lower portion on the tubing string and the tubing leak is usually deep, but the presence of a deep hole in the tubing allows equalization of the two fluid levels.
- Re-shoot the tubing to verify the hole after operating the pumping unit for 30-60 minutes, a hole in the tubing is likely if the fluid level inside the tubing has not risen.
First determined FL to be high in tubing ~ only 274’ from surface.

PCP shut down during night by POC: it stopped bringing fluid to surface. As found w/ fluid in tubing 274’ from surface.

RTT (sec) 0.543

#JTS 8.42

AV 1008 ft/s

Jts/sec 15.51
1st Csg shot w/ PCP turned off showed only 571’ of FAP

Distance To Liquid: 1702 ft

RTIT (sec): 3.376  #JTS: 52.36  AV: 1008 ft/s  Jls/sec: 15.51

Fluid Above Pump: 571 ft  Gas Free Above Pump: 571 ft

Pressure Buildup: 61.3 psi (q) -0.32 psi/min
Downkick showed up 447’ from surface w/ PCP running.
Split on 14 jt down!!! Rod wear on ID!! All other tbg looked really good!!
Tiny split in between threads.
View from the inside.
Pressure Test the Tubing

- Novice Fluid Level Shooters should confirm the hole by pressure test.
- When a tubing fluid level shot and a casing fluid level shot indicates a HIT, then a recommended practice is to confirm the HIT by either calling a pump truck to determine if the tubing can be “loaded.”
- Tubing is usually pressured up to 500 psi(g) and the pressure is held for a period of time.
- If a hole in the tubing is small and near the surface, then a good pump truck can often increase the water injection rate (barrels/minute) to increase the tubing pressure to 500 psi(g).
- But if a hole is present, then the tubing pressure will very quickly leak off (30 seconds to a minute).
- A single leaking tubing collar can take as much as 10 minutes to leak off 500 psi(g) of pressure.
- HIT and a leaky surface casing check valve have many of the same symptoms, but with a HIT the tubing will not pass a pressure test.
Wells that “Kick”

- Excessive amounts of gas produced up the tubing can “unload the tubing”
- Horizontal leg can “kick” large quantities of gas
- After “unload the tubing” occurs
  1. Operator discover the well not producing to the tank
  2. May suspect the well has a hole in the tubing
  3. Foreign material may stick open a valve in the pump
  4. Surface back-pressure may be insufficient.
- Restart Pump action by loading the tubing with water
- Frequent operator intervention required on these wells
- Usually additional back-pressure on the tubing is required
Pumper Reported Well Not Pumping ~ No Fluid to Surface. Arrived on location the well shut-down (HOA on OFF).

ANOTHER WELL WITH UNLOADED TUBING

Initial Cards showed no pump action.
5 min After PU Startup

Casing 4094’ Fluid Level

1st Tubing Shot 4367’ Fluid Level

25 mins After PU Startup

Method 1 - Collar Count

Method 3 - Acoustic Velocity
5 min After PU Startup

1st Tubing Shot 4367’ Fluid Level
25 mins After PU Startup

2nd Tubing Shot 1577’ Fluid Level
147 mins After PU Startup

3rd Tubing Shot 115’ Fluid Level
178 mins After PU Startup

Measured Liquid Rise in Tubing/Rod Annulus
(1577’ – 115’) / 31 min / 8.29 SPM = 5.7 Ft/Stroke
Feet/Stroke Liquid Level Rise Between 1” Rod and 2.875” Tubing Annulus

Measured 5.7 Ft/Stroke Liquid Rise in Tubing Almost Equal to Expected 5 Ft/Stroke Rise
Left Well Pumping with 450 psi Back-pressure

286 BPD Pump Displacement @ 8.29 SPM
Documenting Fluid Movement

- Pump installed in the well was under-performing and not pumping sufficient liquid per stroke into the tubing.
- Dynamometer pump card shows good pump action.
- As the well was produced, the lowered fluid level increased the pressure acting across the plunger and pump slippage increased.
- High differential pressure acting across the PAP plunger, lost pump displacement due to slippage.
- Fluid level shots down the tubing determined whether or not the pump in this well is truly pumping.
- No matter what the “cards” look like, the fluid level shot down the tubing shows the pump is not lifting fluid.
Successive tubing fluid shots show PAP pump was under-performing by not pumping sufficient liquid per stroke.
Feet/Stroke Liquid Level Rise Between 1” Rod and 2.875” Tubing Annulus

<table>
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<th>Shot</th>
<th>Time</th>
<th>RTTT (Sec)</th>
<th>Distance to Liquid (ft)</th>
<th>Elapsed Time (min)</th>
<th>Rise Ft/min</th>
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Calculated

Measured Rise Low
Pump Under Performing

Barracuda State 1Y
SPM 6.59
Fillage 91%
Pump Disp. 127 BBL/D
Measured 1.0 ft/min Fluid Level Rise Too Slow

With no pump slippage the pump should fill approximately 4.25 feet of tubing /sucker rod annular volume per stroke.

170 barrels per day pump displacement
Conclusions

• For Rod Pumped Wells, If no pump action or no production to surface, then shoot a fluid level down the tubing.

• Distance down the tubing typically determined by using the average acoustic velocity obtained from the casing shot.

• Checked for an upkick from the tubing hole appearing on both traces at or near the same depth.

• Dynamometer Pump Card height is less than fluid load determined using fluid level to calculate load required to lift liquid to the surface.

• Monitoring the fluid level in the tubing over time can be used to determine if the pump action is filling the tubing with liquid.

• When data is properly interpreted and acted upon, gassy wells can be operated without frequent intervention.

• Shooting a fluid level inside the tubing is a valuable troubleshooting technique used on wells that have either stopped producing altogether, or production rate has drastically decreased.
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