Acoustic Liquid-Level Determination of Shut-in Reservoir Pressure in Gas Wells

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Introduction/Observations

1. Acoustic liquid level tests are performed successfully on different types of wells throughout the world.

2. Most common use of acoustic liquid level instrument is to measure the distance to the liquid level in the casing annulus of a producing or shut-in oil well.

3. On gas wells an acoustic fluid level tests can provide the similar results as the static gradient surveys.

4. Information can be collected quickly and at low cost.

5. Information is from static acoustic surveys performed on shut-in gas wells in rugged terrain in Canada.
1) No gas/liquid flow into the wellbore.
2) Bottom hole pressure has increased until all flow from the Formation Stops.
3) Includes wells that have been shut-in for an extended time.
4) Usually in shut-in gas wells the gas pressure causes liquid to back flow into the formation.
5) In shut-in gas wells the Liquid Level is often at the perforations.
“There is nothing more important in petroleum engineering than a definite knowledge of the pressure at the bottom of an oil well at any existing operating condition, and the relation of this pressure to the pressure within the producing formation ……. yet there is less information about these pressures than about any other part of the general problem of producing”


* Amerada Petroleum Corporation
Static Bottom Hole Pressure, SBHP

- Energy available to push the gas and fluids to the wellbore.
- Generally GUESSED.
- Need within +/- 15%.
Calculation of SBHP

Static BHP =

Surface pressure +

Gas column pressure +

Oil column pressure +

Water column pressure

Note: Fluids Segregated by Gravity
Gas SG determined from Acoustic Velocity & Fluid SG input.
A Gas Well DOES NOT load up when it is shut-in.

- **Loaded**: There is flow, indicating the well is actively producing.
- **Static**: There is no flow and the well is shut-in.
- **See Perfs & EOT**: Indicates where to observe or measure for further analysis.
DO NOT See Perfs in All Static Gas Wells

Set Tubing Intake Depth?

- **Above** Static Liquid Level for Gas Wells
- **Below** Static Liquid Level for Wells with Down Hole Pump

\[
\begin{align*}
\text{Pt} &= 0 \\
\text{Pc} &= 1230
\end{align*}
\]

- **Static Tubing Loaded**
- **Equalize** May Need Pump
- **Static Pump Dry, but Gas Can Flow**

See Perfs
When a Gas Well is Shut-in

1. Well Head Pressure, $P_t$, is the **Major Portion** of BHP.

2. Pressure, $P_{gc}$, due to Gas Column is Generally Small

$$P_{gc} = \frac{1}{4} \times \frac{\text{Casing Pressure, psi}}{100} \times \frac{\text{Gas Column Length, feet}}{100}$$
Deviation Survey Converts MD to TVD
Calculate All Pressures Based on TVD

Fluid Levels Measure Distance Along Wellbore Deviation
Operator should measure static fluid level and surface pressure in wells shut-in for any reason.

Use Wellbore Description to Identify Downhole Markers.
Static Fluid Level on Gas Well

- Measured Surface Pressure 2249.5 Psig
- 365.8 Psig Gas Column Pressure
- High Pressure Gas Pushed all but 87.8 ft of Liquid Back into Formation
- Easy to Observe Up-kick caused by the top perfs at 6032 feet (Next Slide)
- Collar Recesses Counted to Perforations
Acoustic Trace From Static Fluid Level on Gas Well

Collar Recesses Counted to Perforations

7–8 Sec

100.0 mV

Implosion

Sec 0 1 2 3 4 5 6 7 8 9 10

1000 2000 3000 4000 5000 6000 7000

C-LL

7–8 Sec
Analysis Method of Counting Collars vs Using Top of Perforations as Known Marker Depth

Collar Recesses Counted to Perforations

Depth to LL = 6162.22

6032 ft to Top of Perforations

Acoustic Velocity = 1420 - 1500 ft/sec

Depth to LL = 6164.21
Knowledge of Acoustic Velocity Behavior at Pressure and Temperature is Important

Knowledge of Acoustic Velocity Behavior is important.

- Perfs: 6032 Feet, 150 Deg F, 2640 Psia
- Surface: 0 Feet, 70 Deg F, 2264 Psia
### Determination of Accurate Static BHP

- Accurate calculation of Static BHP requires knowing the distance to the Liquid Level Casing Pressure, and Casing Pressure Buildup Rate.

- Well should be shut-in for a time sufficient to stabilized casing pressure and fluid level.

- Periodic fluid level and casing pressure and casing pressure buildup rate measurements determines if well has reached Static Conditions.

- BHP = Surface Casing Pressure + Pressure from the column of fluids in the annulus.
Shut-in Gas Well - (NO Gas Velocity) Advantages:

- Access to Well Not Restricted by Road Bans or Rough Terrain
- Safer Because of Using Less Manpower and Heavy Equipment
- Inexpensive to use Fluid Level Instruments
- Wire Line Methods Are More Intrusive and Costly

Acoustic Fluid Level Instruments Provides Advantages Over Wire Gauges:

V=0
Acoustic BHP Software

- AWP 2000 program: use with data obtained with strip chart instruments

- TWM program: digital acquisition and processing of acoustic liquid level.

Download free from [www.echometer.com](http://www.echometer.com)
Shut-in Gas Well - (NO Gas Velocity)

Conclusions:

1) **Use Acoustic Fluid Level Surveys to Determine the Static Shut-in Pressures**

2) **Acoustically Determined Bottom Hole Pressures Accurate**

3) **Liquid Level Is Usually at the Perforations in Shut-in Gas Wells**
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