“Holes in Tubing”
a Common Problem in Gas Wells

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Holes in Tubing in Flowing Gas Wells are an Unexpected Common Problem

- Tubing Hole often misdiagnosed or over-looked.
- Production Rate Drop looks like Liquid Loading due to Flow Falling Below Critical Rate
- Reduced gas rate is frequently misdiagnosed
- Problems occur gradually as hole size increases
- Lift methods being applied to unload the gas well often fail due to a hole in the tubing.
- Case studies will show significant increases in gas production after repair of Hole.
General Description

• Most Tubing is EUE J-55 Steel
• Holes in Tubing more common in wells without Packer, but see holes in tubing with Packer
  – Occurrence of Hole in Wells With Packers easier to Detect, due to pressure communication
• Common to treat Surface lines with Corrosion Inhibitor, less likely to treat with Chemical Downhole
• Using a wire-line to set a standing valve and pressure test the tubing is normal costly method to test for hole.
Look Down Tubing with Acoustic Surveys to see What is Downhole

@ 4750 Ft
Tight Spot in Tubing
Bumper Spring

@ 4325 Ft
1/8 x 1/4 in.
Small Hole in Tubing

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Holes are Unexpected Problem

- For Example: >12% of 235 flowing gas wells analyzed were found to have holes in the tubing, where no holes were thought to exist.
- Tubing and Casing Pressure are Not Equal with Hole
- When flow up tubing; High Fluid Level in Casing Likely Indicates a Hole in the Tubing
- Holes are commonly seen at particular depth range in the well
Use an Acoustic Fluid Level Instrument To Identify The Depth To The Hole

1. Shoot tubing/casing annulus while flowing up tubing

   • Fluid Level should be near tubing intake or below perforations (If no Hole)
Use an Acoustic Fluid Level Instrument To Identify The Depth To The Hole

Shoot down tubing and tubing/casing annulus

1. Shoot tubing/casing annulus while flowing up tubing
   • Fluid Level should be near tubing intake or below perforations (If no Hole)

2. Shut-in well, continue to shoot casing annulus looking for down kick due to liquid leaking from hole in tubing back into annulus.

3. Increasing Pressure pushes liquid down

4. After 1-2 hours of shooting tubing and/or casing annulus an upkick from hole should be seen.
Gas Well Production Curve - Flow Rate

Dramatic Drop in Rate
820 Mscfd → 250 Mscfd

Small hole Began to Cause Problem

Drop in Production due to Liquid Loading?
Shot Fluid Levels to
Open Sliding Sleeve and Commingle Two Zones

Found Hole in Tubing
With Fluid Level Shot

Turner Critical
320 MscfD

Replaced Tubing and Gas Flow
Returned to 2006 Rate
Can’t be a Hole ~ Tubing is New
Hole @ Depth 4325 Ft from Surface
Hole Not Visible

Time 12:12:27  Csg 125.9 Psi
Shot Casing/ Flowing Up Tubing

Time 12:24:15  Csg 135.5 Psi
Shot Casing/ Tubing Flow Shut-in

Time 12:29:14  Csg 138.8 Psi
Shot Casing/ Tubing Flow Shut-in

Time 12:35:58  Tbg 143.1 Psi
Shot Tubing/ Flow Shut-in

Time 13:09:38  Tbg 150.8 Psi
Shot Tubing/ Flow Shut-in

Hole @4325 Ft
Gas Well Production Curve - Flow Rate

- Dramatic Drop in Rate
- Well Appears to be Liquid Loaded, due to drop off Decline Curve. Shot Fluid Level to Investigate Conversion to Plunger Lift.
- Found Hole in Tubing
- Turner Critical 300 MscfD
- Swabbing w/ Plunger to Remove Kill Fluid.
- 15 m3 Remain
- Killed Well to Replace Tubing
- 640 Mscfd ➔ 100 Mscfd

640 Mscfd ➔ 100 Mscfd

300 MscfD

2005 2006 2007 2008

Time - Years

E3m3

MscfD
Many Holes in Tubing Joints (118-121)

Hole Depth 3730.1 Ft. / 31.657 Ft/Jt = 117.9 jts from surface

Outside Pipe

Inside Pipe
**Shot Down Casing Should Show Liquid Level near Tubing Intake Depth of 6816’**

<table>
<thead>
<tr>
<th>Select Liquid Level</th>
<th>Depth Determination</th>
<th>Casing Pressure</th>
<th>BHP</th>
<th>Collars</th>
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Well Flowing up Tubing, Shot Down Tubing/Casing Annulus Shows LL @ 5213 ft with Tubing Intake 6816 ft.

Use 0.6616 Gas SG for Distances

Liquid Level: Likely Hole 3730 Feet
Up-kick at Same Depth in Tubing/Casing Well Shut-in 1.5 Hrs, Shot Down Tubing

Counted Collars for Distances

Likely Hole 3724.6 Feet

Liquid Level
Gas Well Production Curve - Flow Rate

04/30/07 Liquid Loading supported installing plunger

Service rig 7/27/07 Replaced tubing; more sand troubles; plunger working now

6/6/07 plunger equipment was installed and then realized a hole.
1. Well was Liquid Loaded
2. Fluid Level Shots Showed Tubing was OK
3. Installed plunger and couldn’t surface the plunger
4. Took more shots.
5. Then the upkick showed up in the as the well was shut in for a while.
6. Original shots did not expose the hole in the as the well was loaded up with Gassy Liquid Above Hole

Tubing Hole (No Blast Joint) Sand Blast
Gas Flow From Upper Set of Perforations
Shots Down Tubing & Casing

Hole in Tubing @ 6868'

Tubing Shot

Casing Shot
Tubing Press Change When Plunger Falls Past Hole

Plunger Fall Velocity Gradually Increases?

Drop Plunger to Count Joints to Hole

Plunger Hits Liquid @ 6945'

Elapsed Time - Mins

Plunger Fall Velocity - F/min

Death to Plunger - Fall

Data Points
Use an Acoustic Fluid Level Instrument To Identify The Depth To The Hole

Track Plunger or Soap Stick as it Falls Past Hole

1. When Completed shooting Fluid Levels
2. Release Plunger/Soap Stick and Track Fall
3. Tubing pressure decreases by 2-3 psi at Start
4. Pressure increases when falls past hole
   - Fast pressure increase BIG Hole
   - Slow Pressure increase Small Hole
5. Plunger Velocity changes at Hole
Pressure Increases as Plunger Falls Past Hole

Plunger Fall in Well with Hole in Tubing - Tubing and Casing Pressure Equalized
Notice Tubing Pressure Drops approx 3 psi when Plunger Begins Fall
Pressure Drop Begins to Equalize When Plunger Falls Past Hole

Pressure Drop due to:
Weight/Area = 2.31 Psi
Terminal Velocity Force
Friction on Plunger

Hole Depth: 5050 Feet
Fall Velocity Constant Above Hole

Average Fall Velocity 217 Ft/Min

Past Hole Slows ~ 200 Ft/Min

Slower
Faster

146 Feet of Liquid in Bottom of Tubing
Conclusions

• DO NOT be surprised if more than 10% of your liquid loaded gas wells have holes in the tubing.

• Hole Causes Significant Drop in Gas Production.

• Large gas production increase is possible due to repairing the hole in the tubing and returning the gas well to unloaded flowing state.

• Using an acoustic fluid level instrument is a low cost, quick method to troubleshoot a gas well and to identify the presence/location of a hole.

• Tracking plunger and soap stick is a good method to confirm presence of a hole.