Tubing Backpressure
Sometimes Required on Gassy Sucker Rod Lifted Wells

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What Defines a Gassy Sucker Rod Lifted Well

1. **Flumping** - the well is flowing fluids to the surface up the casing annulus, plus at the same time fluids are being lifted up the tubing to the surface

2. Wells flump because:
   - High producing bottom hole pressure and/or
   - High gas rate flowing up the casing annulus; lightening the fluid column above the formation.

3. Up the tubing gas lightens the tubing gradient and the well flows ff and pump actions stops.
Presenting Data Showing Impact of Gas Up Tubing on Sucker Rod Lifted Well

1. Field Dynamometer Data Collected on a Gassy Sucker Rod Lifted Well
   a) Having Pump Problems because too Much Gas is Being Pumped up the Tubing
   b) Tubing Unloads while Acquiring Dynamometer Data
   c) Pump Action Stops.
   d) Various Pump Conditions based on Dynamometer Card Shapes will be Shown.

2. Dynamometer Data was Acquired Using a Calibrated Horseshoe Load Cell
On a Well Producing a Lot of Gas. What does it mean? When:

Gassy Fluid Level Near Surface

- Casing Pressure: 171.6 psi (g)
- Casing Pressure Buildup: 59.1 psi, 15.00 min
- Gas/Liquid Interface Pressure: 172.3 psi (g)
- Liquid Level Depth: 126.50 ft
- Pump Intake Depth: 4997.00 ft
- TVD: 4997.00
- Formation Depth: 6565.00 ft

Well State:

- Producing

Annular Gas Flow: 124 Mscf/D

% Liquid: 22%

Liquid Below Tubing:

- Oil: 0%
- Water: 100%
- % Liquid Below Tubing: 48%

Pump Intake Pressure: 531.7 psi (g)

PBHP: 875.5 psi (g)

Reservoir Pressure (SBHP): 1800.0 psi (g)

No Pump Action ~ Weigh Rods in Air

- Fo Max
- Fo From Fluid Level
- Wrf
- Wrf + Fo Max

Subtract Weight Rods in Air and Pump Card on Zero Load Line

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Calculated Pump Card Loads:

**SV Open Upstroke:**
- \( Fo_{Max} = (P_{dis} - 0) \times Ap \)
- \( Fo = (P_{dis} - P_{intk}) \times Ap \)

**TV Open Downstroke:**
- \( Fo = 0 \)

Pump Card Reference Lines:

1. **Fo Max** - assumes pump intake pressure is zero, where well provides no help in lifting the fluid to the surface.
2. **Fo From Fluid Level** - assumes pump intake pressure determined from fluid level shot, where well's PIP provides help in lifting the fluid.
3. **Zero Load Line** - pump card sets on zero load line because rods in tubing fluid with pressure above and below the plunger equal; no friction due to fluid displacing through TV on down stroke.

**Surface Card**

- Pump Card
- Fo Max
- Fo From Fluid Level
- Wrf
- Wrf + Fo Max
- Well

Fluid Load Lifted by Rods

- Fo ~ Height of Pump Card

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Steps C - D in Pump Operation

Pump acts as a Compressor

PDis - Discharge Pressure
PB - Pressure in Barrel
Pintk - Intake Pressure

C) Standing Valve closes, when plunger reaches top of stroke, rods start to un-stretch to transfer fluid load, Fo, from rods [C] onto tubing [D].

D) Traveling Valve Opens when pressure in pump barrel >= Pump Discharge Pressure, PDis.

C-D) Plunger applies pressure to fluids inside pump barrel, to compress fluids in Pump barrel and increase pressure.
No Pump Action Shown as Flat Pump Card Load Lines

1) **TV Stuck Open** - Pump card on Zero Load, Looks like Deep Rod Part but often can tag or jar the rods and knock the debris out of the pump and re-start pump action.

2) **SV Stuck Open** – Plots on the Fo from the Fluid Level line

3) **Tubing Blown Dry** – Missing Buoyancy, plots as a flat line @ a height of Wra-Wrf lbs above the zero load line..
Gas Filled Pump Card Means that Free Gas is Being Pumped up the Tubing

Strokes 1-146 gas interference ~ gas pumped into the tubing

Stroke 147-186 No Pump Action

Gas Compression

TV Stuck Open!
Gas Through the Pump Can Interfere with the Normal Valve Action

Stroke 187 TV Delay Going on Seat

Stroke 188 More Gas Up the Tubing

TV Goes on Seat

Gas Compression

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Flat Pump Card Means No Load Transfer Between SV and TV

Stroke 189 Pump Full of Gas

Stroke 190-314 SV Open

Some Call This a Gas Locked Pump

SV Stuck Open and TV Stays Closed.

Flat Pump Card Means No Load Transfer Between SV and TV

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Pumping Gas Into Tubing, Then Light Gassy Gradient Unloads Tubing, No Pump Action as Rods Hanging in Tubing Filled With Gas.

Next 470 Strokes

Fluids in Tubing Flow Off

Pump Fillage 50%
Lots of Gas up Tubing
Gas Compression

Tubing Liquids Have Blown Out and Rod Buoyancy Missing
Missing Buoyancy

Load Cell Weighing Rod Weight in Air

Pump Fillage 50%
Lots of Gas up Tubing
Gas Compression

Tubing Liquids Have Blown Out and Rod Buoyancy Missing
Missing Buoyancy

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1. Use of a tubing back-pressure regulating valve maintains pump action and prevents unloading of tubing liquids.

2. Back-pressure allows pump action to be maintained when differential pressure across plunger is low due to lightened tubing liquids from gas entering (pumped into) the tubing.

3. Surface tubing discharge pressure is higher when compared to the surface pressure if no backpressure regulating valve were present.

4. Additional tubing backpressure results:
   • Increased pressure at the pump discharge
   • Requires additional horsepower
   • Increased rod, unit, and motor loading
   • Potentially higher operating cost to *pump the well*
Use of Backpressure Regulating Valve on Tubing of a Sucker Rod Lifted Well

1. Previous Dynamometer Data Acquired Using a Calibrated Horseshoe Load Cell While the Tubing Discharge Pressure Was too Low

2. Backpressure can Prevent Tubing Fluids from Unloading
   - Unloading usually Caused by Poor Downhole Gas Separation with Gas Pumped into the Tubing
   - Tubing Fluids Lighten and Tubing Liquids Flow Off.

3. Best to Keep Gas Out of the Tubing by Setting the Pump Intake Below the Perforations

4. Or Use an Effective Downhole Gas Separator to Keep Gas Out of the Pump
Basic Principles of Downhole Separator System

- Downhole separators must be efficient, low cost, trouble free, long lasting.
- Gravity separation is the governing principle for plunger pump installations.
- Many designs have been proposed (over 75 US patents) but only those that satisfy the above conditions are used in practice.
Gas Separator Summary

- Best gas separation efficiency by locating pump intake below gas entry point.
- Poor Boy gas separators tend to be ineffective because of limited liquid capacity due to small flow area inside separator.
- Improved efficiency by maximizing flow areas for gravity separation.
- Proper gas separator selection must take into account gas production rate and pump liquid capacity.
- High Capacity Gas Separators should be considered.
Tubing Backpressure Impact on Pump with 50% Fillage

425 Psi Tubing Backpressure

PPRL = 12149 Lbs
PR HP = 3.3
MPRL = 5936 Lbs

Wrf + Fo Max
Wrf
Fo Max
Fo From Fluid Level

200 Psi Tubing Backpressure

PPRL = 11935 Lbs
PR HP = 2.9
MPRL = 6639 Lbs

Wrf + Fo Max
Wrf
Fo Max
Fo From Fluid Level
1. Backpressure regulating valve used to increase the tubing pressure.
2. Additional tubing backpressure results in increased pressure on the pump discharge and requires additional horsepower at the pump to lift the fluids to the surface.
Prevent Unloading Up The Tubing by Using a Backpressure Valve

Gas Flowing through Pump OR Pumped into Tubing

- **Backpressure valve** maintains high tubing pressure to prevent gas from blowing all of the liquid out of tubing
- **Without BPR** Pump action erratic & discharge may STOP

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**Pressure Gage**

**Increase Pressure by Compressing Spring**

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**Flow**

**Spring Force**

**BPV**

Harbison-Fischer Model Illustrated

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Some Stuffing Boxes Can Increase Friction on Polished Rod

1. Tubing Backpressure Acting On Some Types Of Stuffing Boxes Can Result In Additional Friction Applied To the Polished Rod.

2. Pump Card Shows The Impact From The Additional Friction If Not Removed by Calculations at the Surface.

3. Extra Stuffing Box Friction:
   a) Increases Horse Power
   b) Increases Upstroke Loads
   c) Decreases Down Stroke Loads
1. Compare Back-pressure regulating valve used to increase the tubing pressure from 250 and 1000 Psig

2. Backpressure reduces the polished rod load (the polished rod load is reduced by a piston force equal to the back pressure times the area of the polished rod).

\[
\text{Piston Force} = \text{Back-pressure} \times \text{Area of Polished Rod}
\]
Compare 250 to 1000 Psig Backpressure

Current Production:
25 BWPD, 180 BOPD, 300 MscfD

Load - Klbs

Stroke Length - Inches

Tubing Head Pressure 250 Psig

Tubing Head Pressure 1000 Psig

PPRL = 12057
PPRL = 13046

MPRL = 6568
MPRL = 5795

Pump HP = 3.1
Pump HP = 7.0
Use of Backpressure Regulating Valve on Tubing Results in

1. Increased the tubing fluid gradient
2. Increased the fluid load applied by the pump to the rods
3. Increased polished rod horsepower
4. Increased Rod loading with Higher Stress Range.
5. Increased the load on the prime mover
6. Reduced the plunger effective stroke length due to increased static stretch
7. Reduced in the pumping speed, due to motor slip
8. Reduced the effective pump displacement
9. Increased frictional forces the stuffing box applies to the polished rod.

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Issues Using Backpressure

1. Overall System Efficiency will be Less

2. Backpressure impacts measured surface loads

3. Sucker rod loading can be incorrect, because of the piston force, rod loading below the surface will be higher than measured

4. **Use Backpressure ONLY IF** a well is Flowing Off due to **TOO Much Gas Produced Up the Tubing**

5. If the tubing unloads and pump action stops, then try 200-300 Psi of backpressure on the tubing **BUT** use more if required by well
Benefits of Backpressure

1. Maintain Pump Action
2. Reduced Well Intervention by the Operator
3. Significantly Reduced Stuffing Box Leaks
5. Backpressure May Increases Operating Cost, But Allows You to Pump the Well
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