Weatherford®

WCVR – Critical Velocity Reducing System

A Creative Combination of:

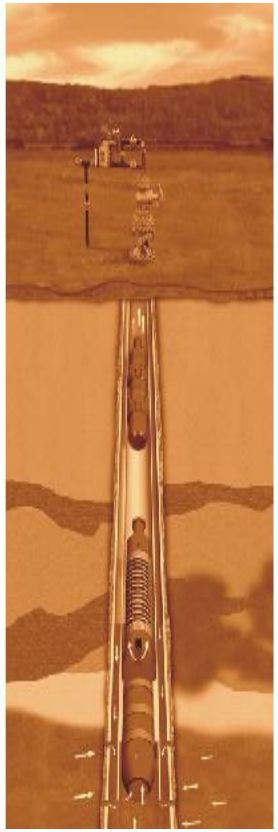
- **Area Reduction**
- **Surface Tension and Density Reduction (Foamer)**
- **Plunger Lift**

T. Scott Campbell
Global Business Development Manager
Deliquification Solutions

Artificial Lift Systems:

Only company offering all forms of artificial lift worldwide

Electric Submersible Pumping (ESP)

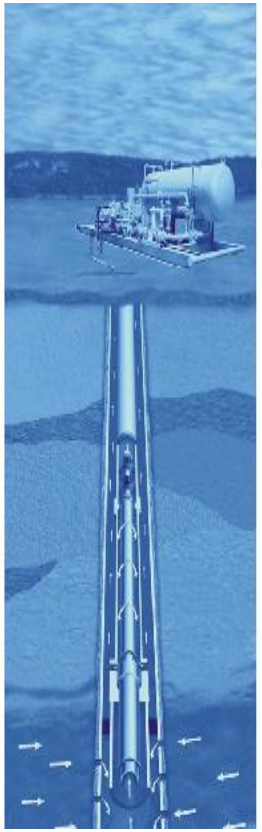


Plunger Lift

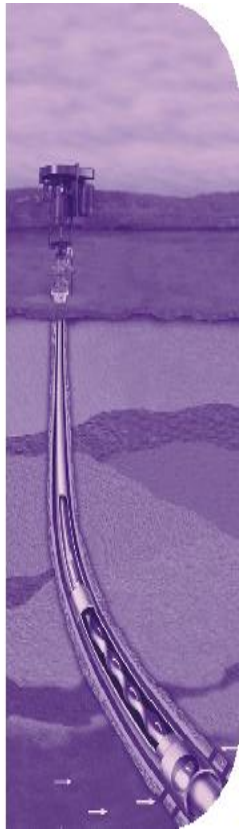
Reciprocating Rod lift

Gas Lift

Foam Lift (Capillary)



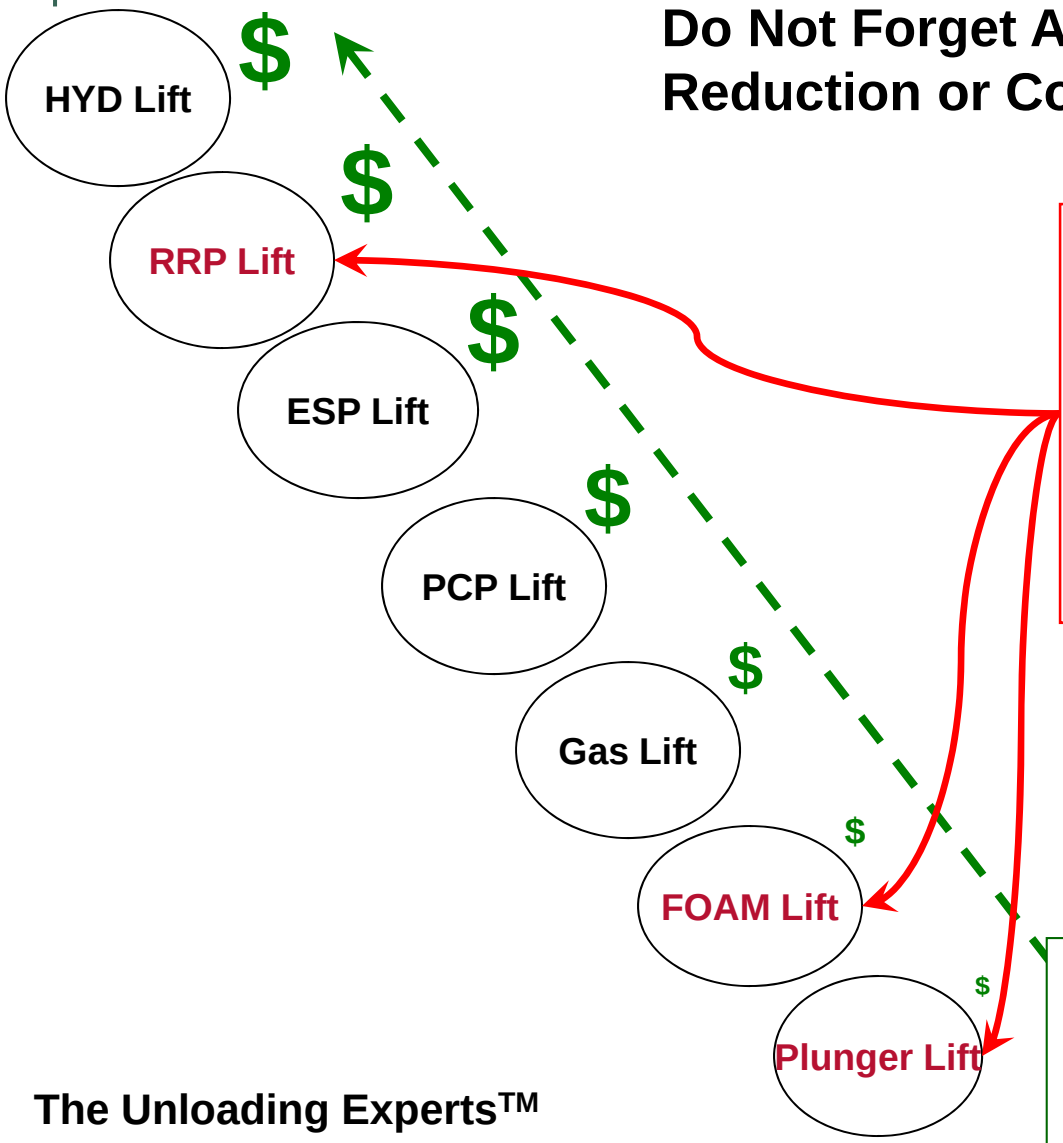
Hydraulic Lift



Progressing Cavity Pumping (PCP)

Our “Toolbox” – The Best in The Industry

The Unloading Thought Process Versus Cost



Do Not Forget About Area Reduction or Compression!!!!!

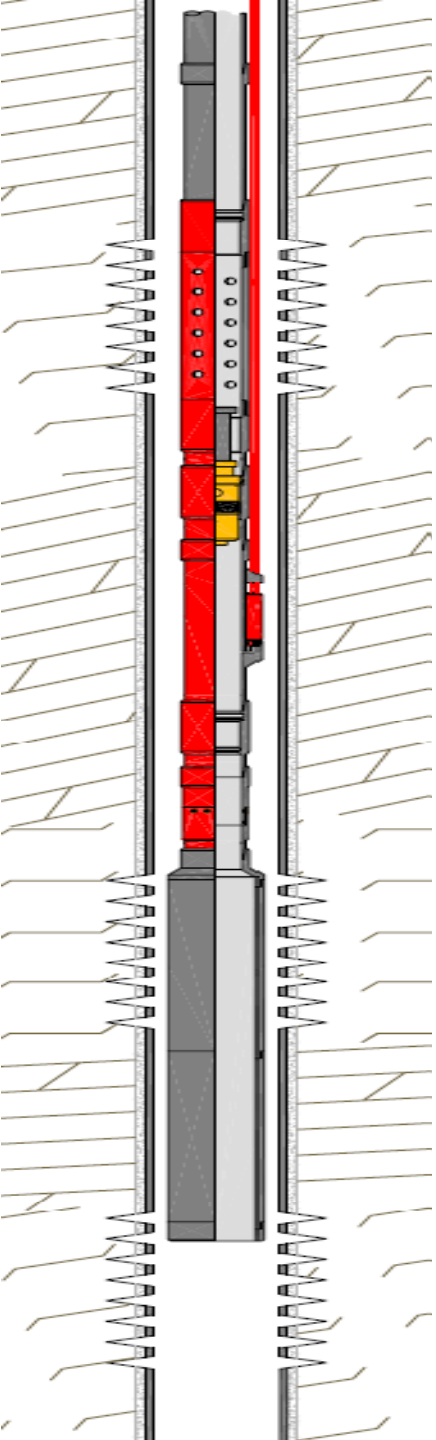
MOST "Lifted" GAS WELLS

are either..

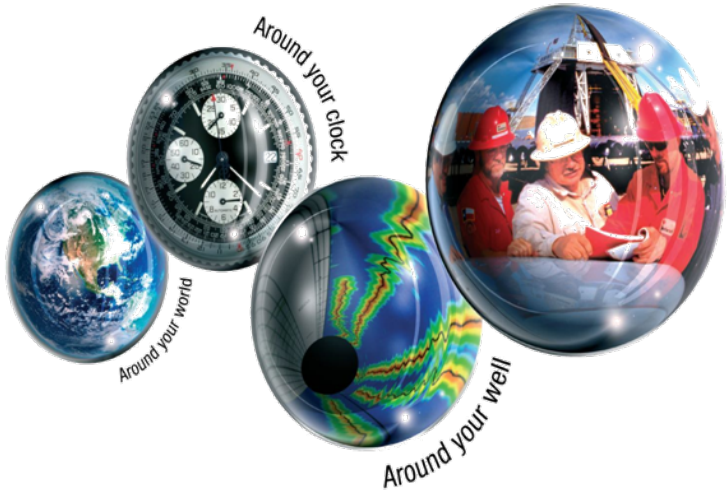
PLUNGER LIFTED
FOAM LIFTED
OR ROD PUMPED

Generally,
Cost of LIFTING GAS WELLS INCREASES

The Unloading Experts™



Weatherford®



All Around You

CVR System

Critical Velocity Reduction

Combination of Area Reduction, Capillary Injection Foamer and Plunger Lift to Reduce Required Critical Velocity

Example Completion:

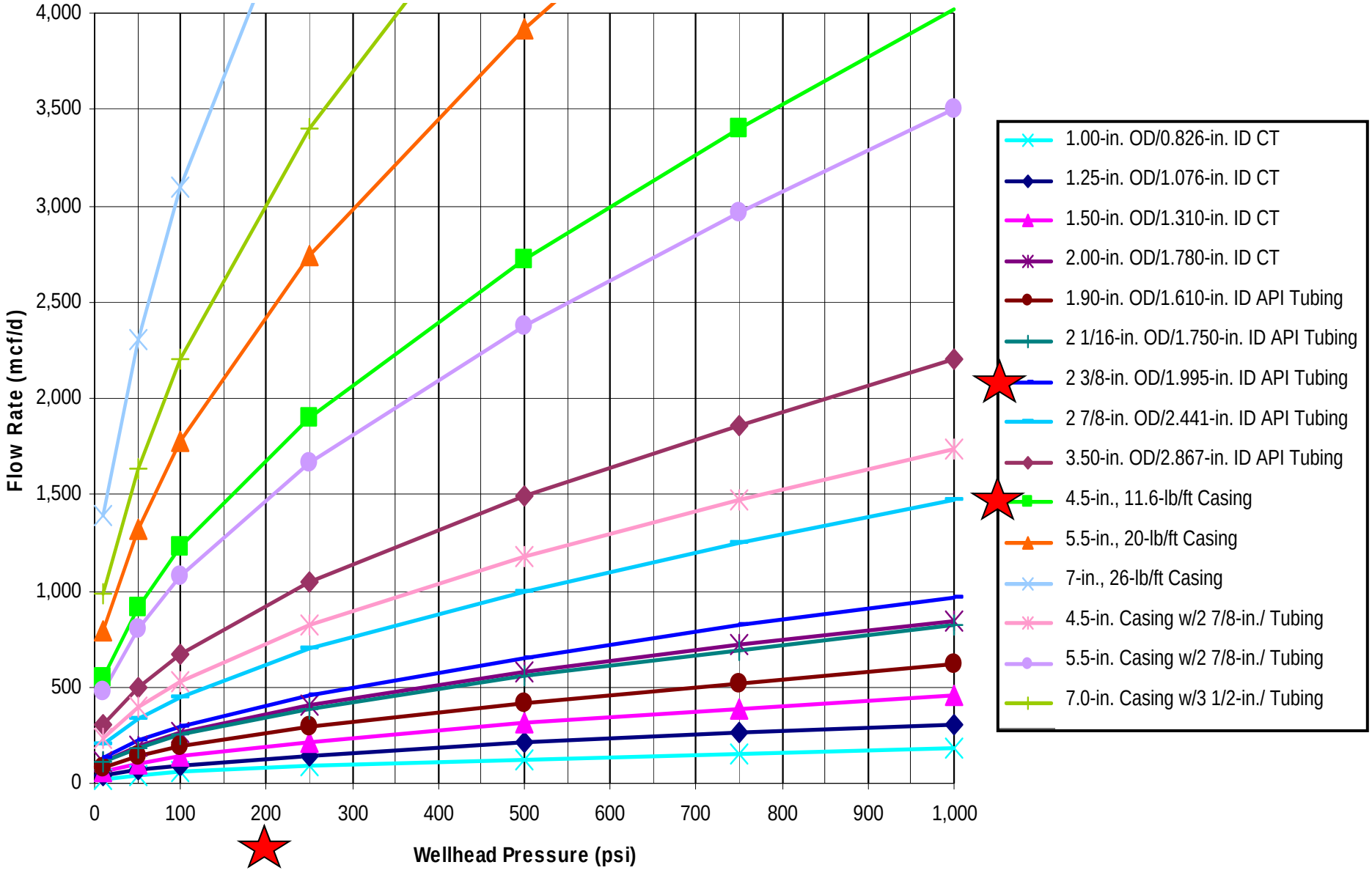
2 3/8” Production Tubing

4 ½” Casing 11.6# Casing

200 PSI Line Pressure

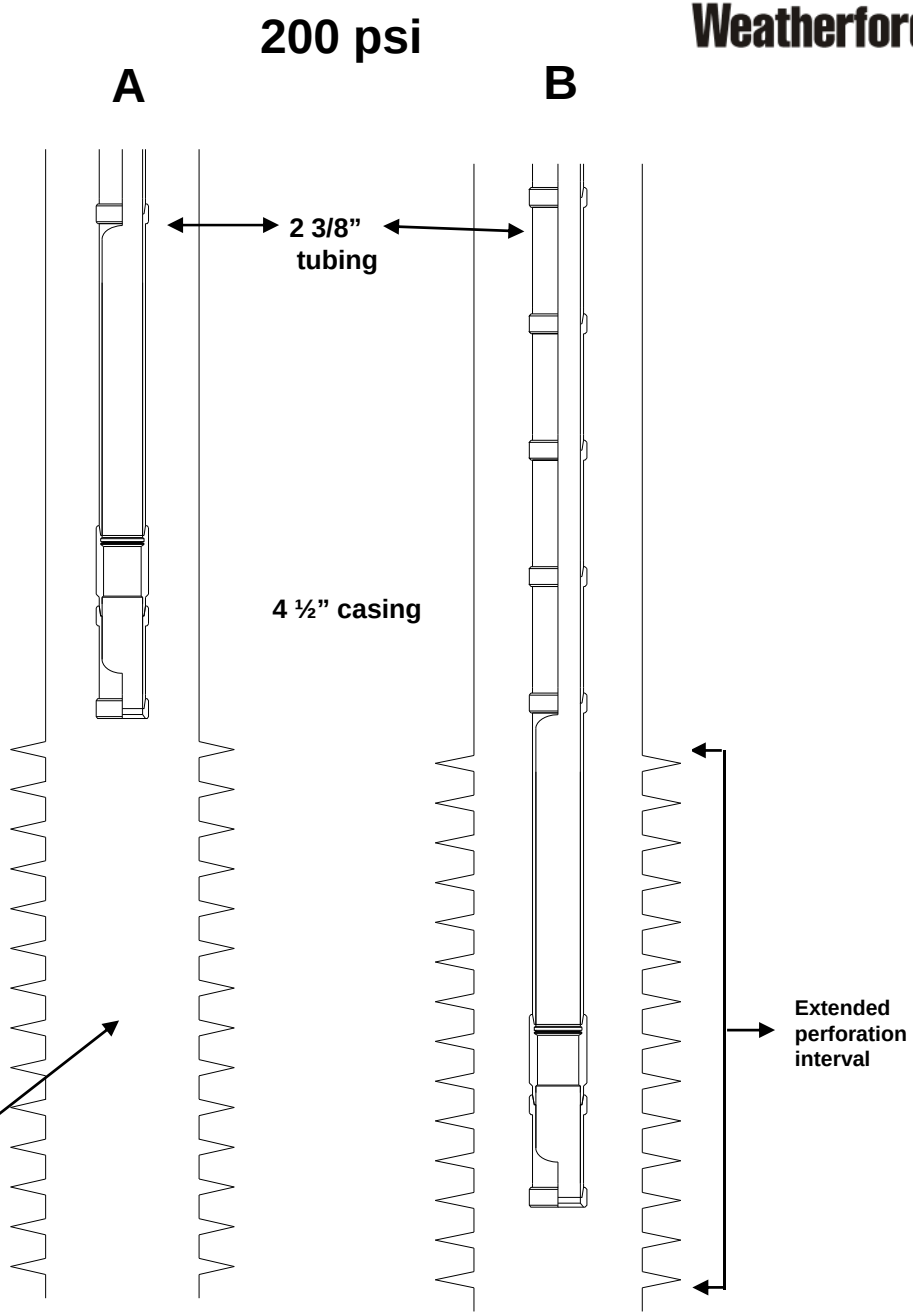
Extended Perforation Interval

Critical Flow Rates



Typical Completion

- Production String:
  - 2-3/8”, 4.7 lbs/ft
- Casing:
  - 4-1/2”, 11.6 lbs/ft
  - Flow area: **12.5683 in.^{2}**



Critical flow requirements assuming **200-psi** WHBP(FTP):

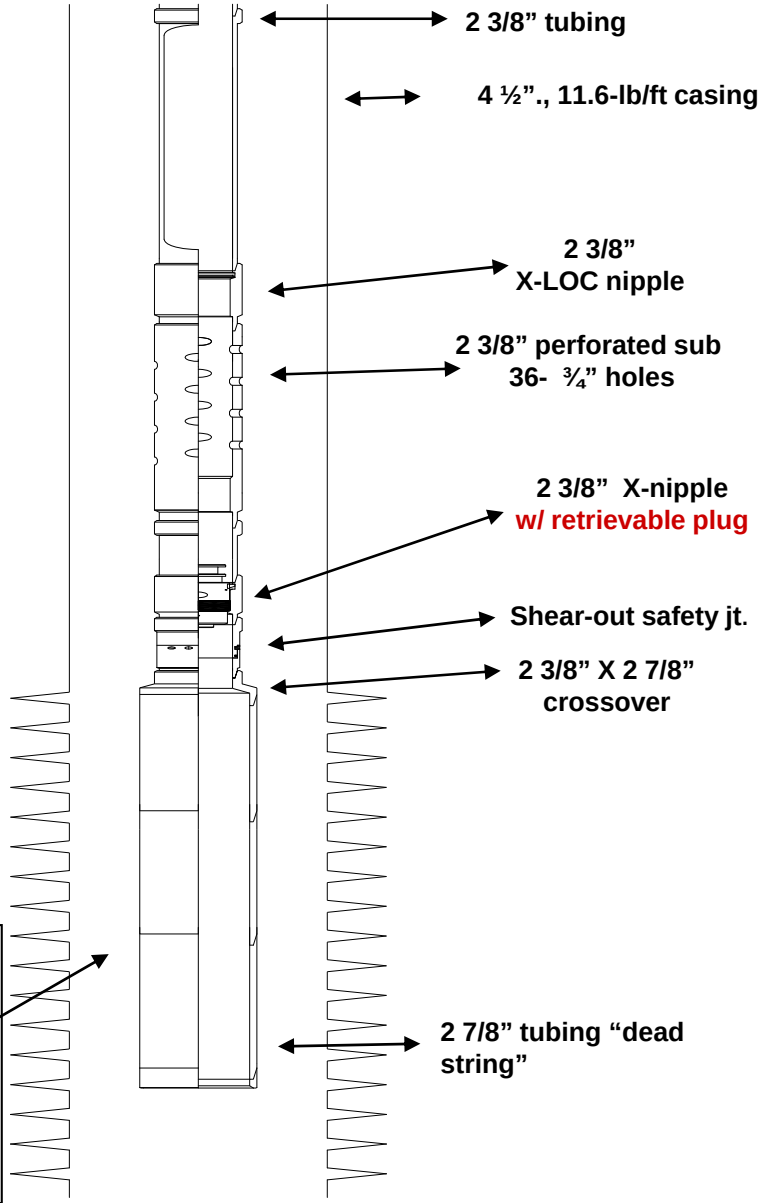
CFR for 2-3/8” = 406 mcf/d
CFR for 4-1/2” = 1.63 MMcf/d

4 ½” Casing, 2 7/8” Dead String Only

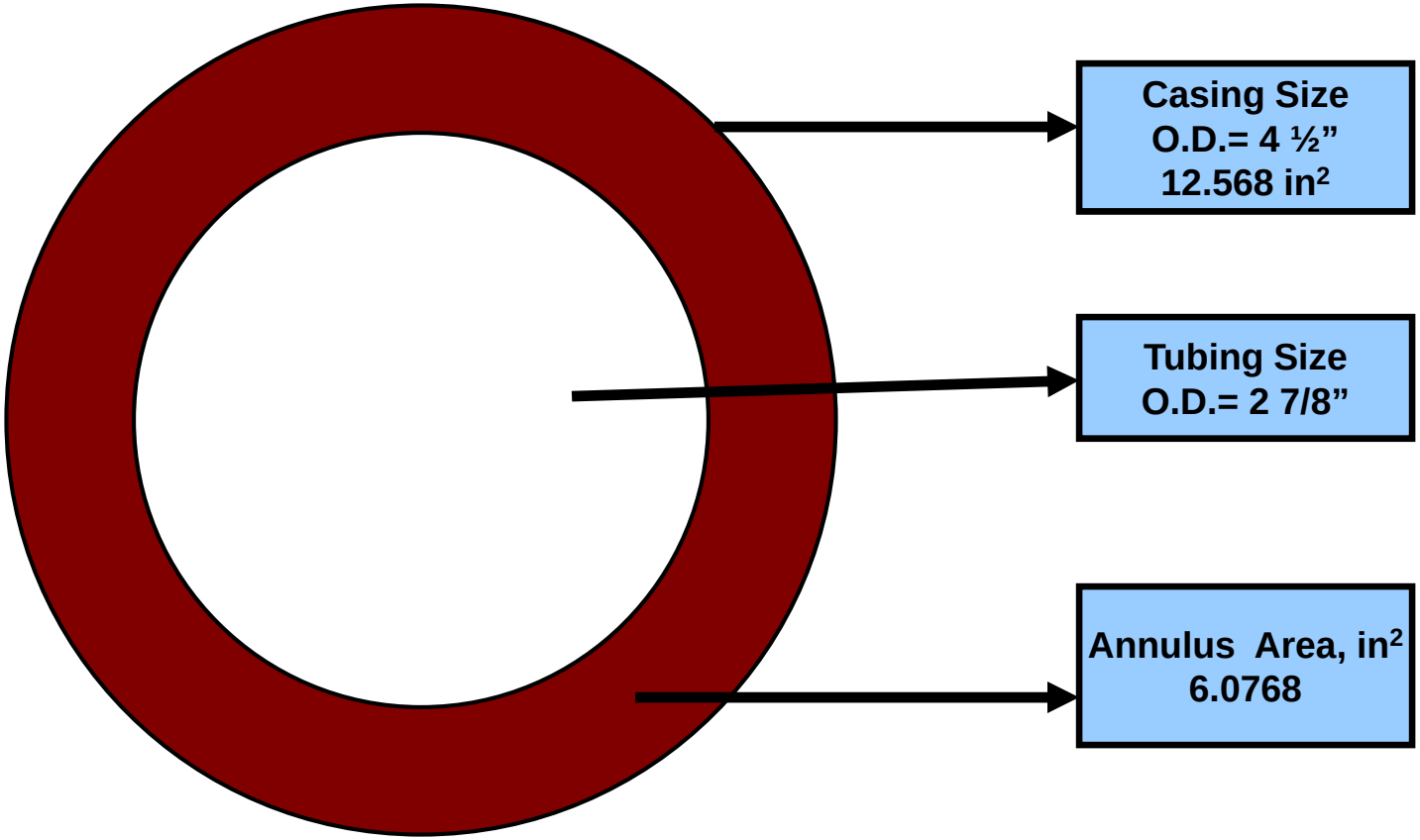
- Dead String: 2 7/8” ULTRA FLUSH
  - NO couplings = 2 7/8” = 2.875” OD
- Casing: 4-1/2”, 11.6 lb/ft
  - Flow area: **12.5683 in.^{2}**
- Annular flow area, 2-7/8” inside 4-1/2”
  - Flow area: **6.0768 in.^{2}**

Critical flow requirements assuming 200-psi WHBP:

CFR for 2-3/8” = 406 mcf/d
CFR for 4-1/2” x 2 7/8” annulus = 790 mcf/d
(was 1.63 MMcf/d with open 4 ½” casing)



4 ½” Casing, 2 7/8” Tubing



Creating the Dead String Effect

4 ½” Casing, 2 7/8” Dead String with Capillary String for Foamer Injection

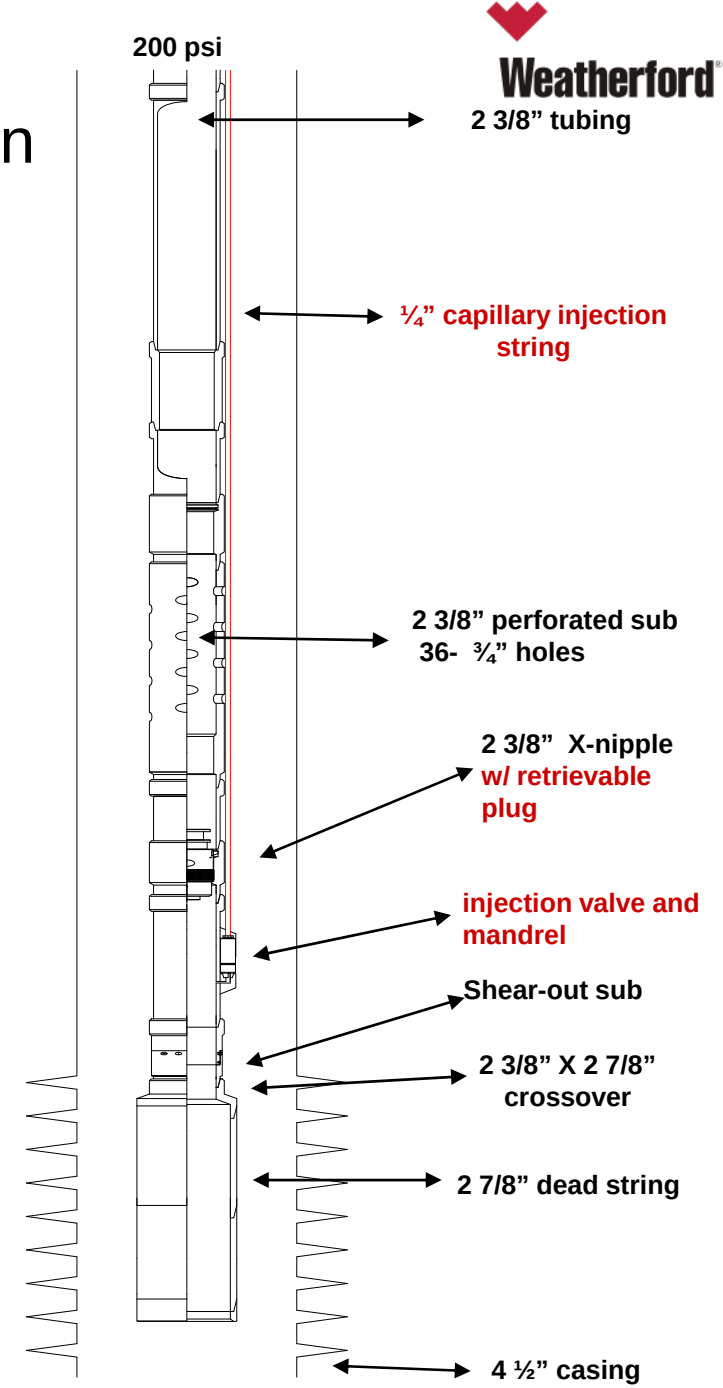
- Casing: 4 ½”, 11.6-lb/ft casing
  - Flow area: **12.5683 in.^{2}**
- Annular Flow Area: 2-7/8” inside 4-1/2”
  - Flow area: **6.0768 in.^{2}**

Critical flow requirements assuming 200-psi WHBP:

2 3/8” = 168 mcf/d with foam
(was 406 mcf/d without foam)

4 ½” x 2 7/8” annulus = 327 mcf/d with foam

(was 790 mcf/d without foam)
(was 1.63 MMcf/d without Dead String)

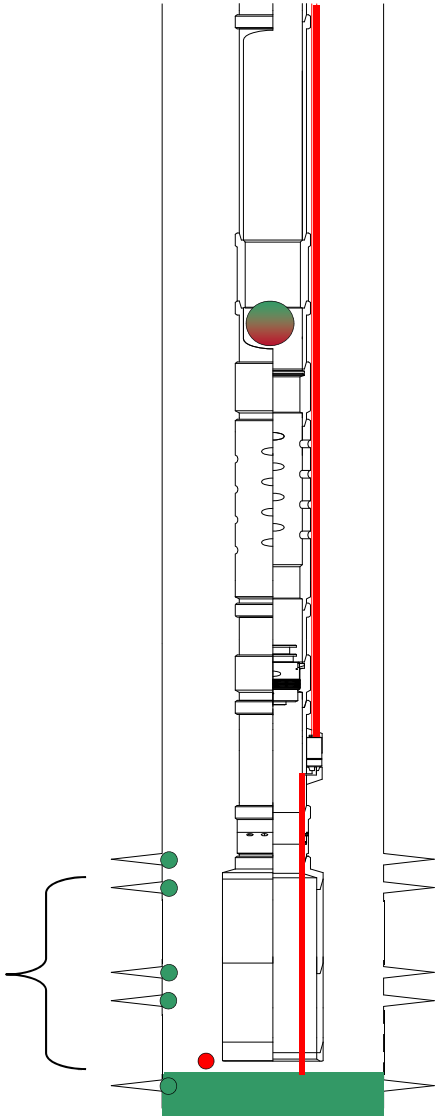


Patented System

New Wellbore Configuration

2 7/8-in. “Dead String” below 2 3/8-in. Tubing With Foamer and Scale Inhibitor Injection

Patented System

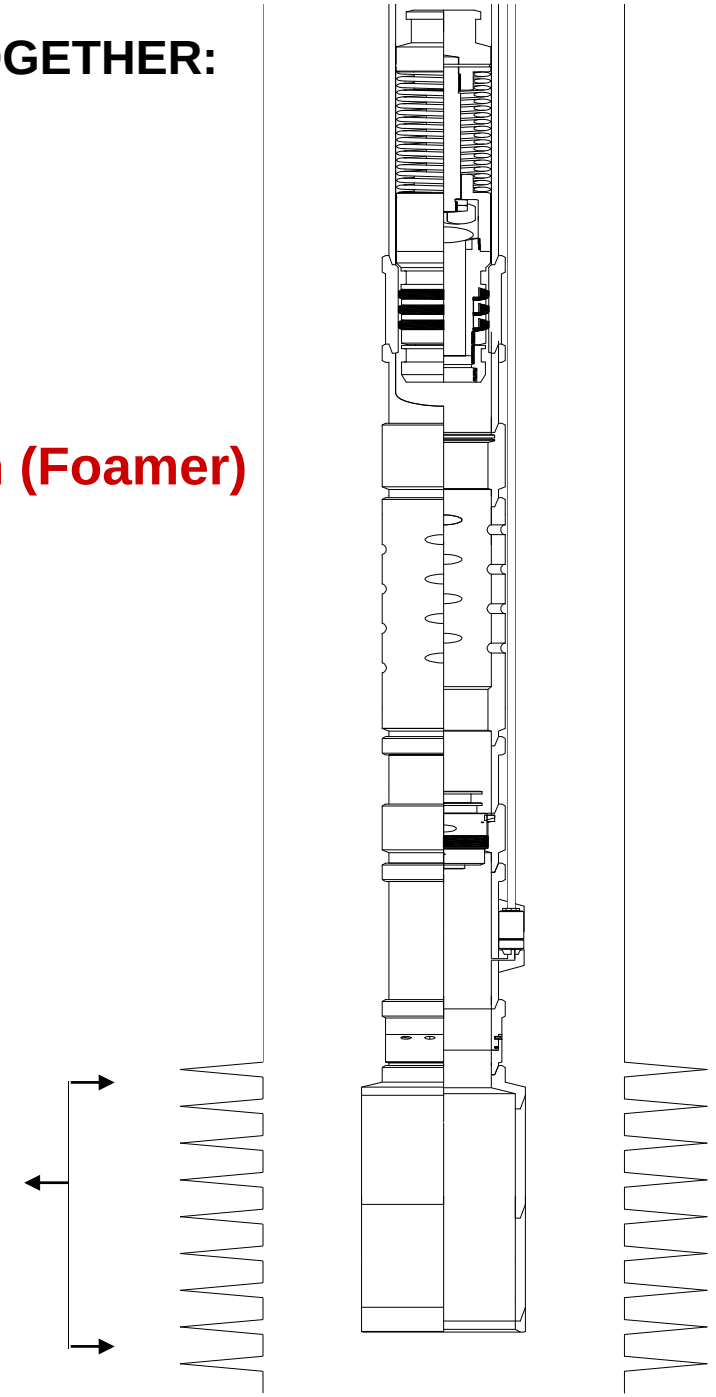


“Dead String”

THREE ARTIFICIAL LIFT SYSTEMS WORKING TOGETHER:

- Area Reduction (Dead String)
- Surface Tension and Density Reduction (Foamer)
- Plunger Lift (Mechanical Interface)

Patented System



Weatherford

FWHP = 200 PSI

Flow Pattern	Flow Area (ft^2)	Flow Area ($in.^2$)	CV with Water, (ft /sec)	CV with Foam, (ft /sec)	CFR with Water (mcf/d)	CFR with Foam (mcf/d)
2 3/8-in., 4.7-lb/ft tubing	0.02171	3.1262	15.70	6.50	406.70	168.4
2 7/8-in., 6.5-lb/ft tubing	0.03250	4.6800			608.80	252.1
3 1/2-in., 9.20-lb/ft tubing	0.04883	7.0315			914.70	378.8
4 1/2-in., 11.6-lb/ft casing	0.08728	12.5683			1,634.90	676.9
5 1/2-in., 17-lb/ft casing	0.13054	18.7978			2,445.40	1,012.5
2 3/8-in.tubing and 4 1/2-in. casing	0.05650	8.1360			1,058.50	438.3
2 3/8-in. tubing and 5 1/2-in. casing	0.09978	14.3683			1,869.00	773.9
2 7/8-in. tubing and 4 1/2-in. casing	0.04220	6.0768			790.30	327.2
2 7/8-in. tubing and 5 1/2-in. casing	0.08550	12.3120			1,600.80	662.8
3 1/2-in. tubing and 5 1/2-in. casing	0.06372	9.1757			1,193.70	494.2

Installation Pictures

and

Production Data

Weatherford®

Installation Photos

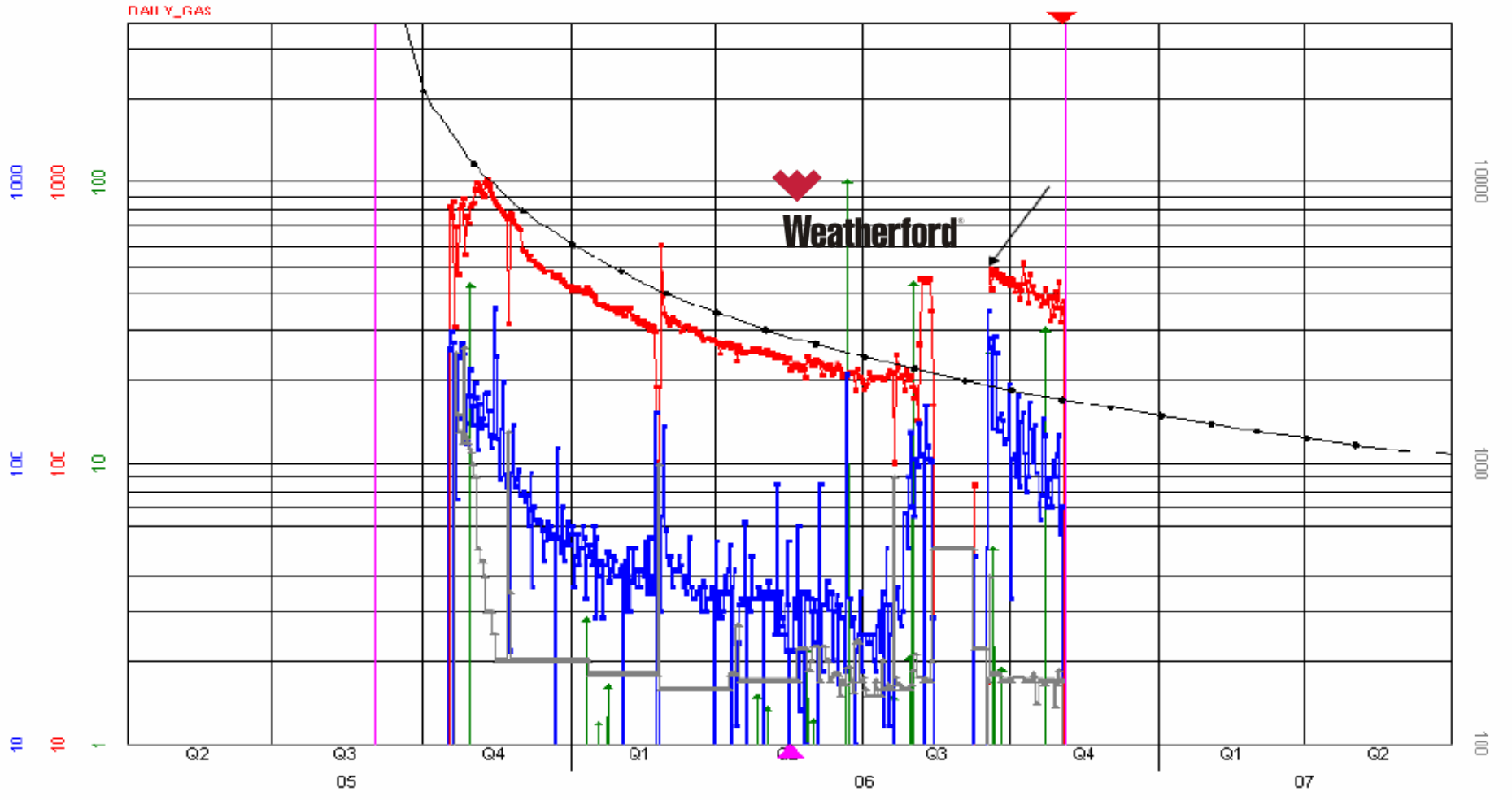
1. CVR Assembly in Elevators
2. ¼” Capillary String @ Valve
3. Stainless Bands

Installation Photos

1. BOP and Hydril
2. Ultra Flush Box and Pin
3. Ultra Flush Connection
4. Extended Neck Tubing Hanger
5. Adapter Flange

Example Well C

Example Well D: Redefine the Decline Curve!



Potential CVR Candidates

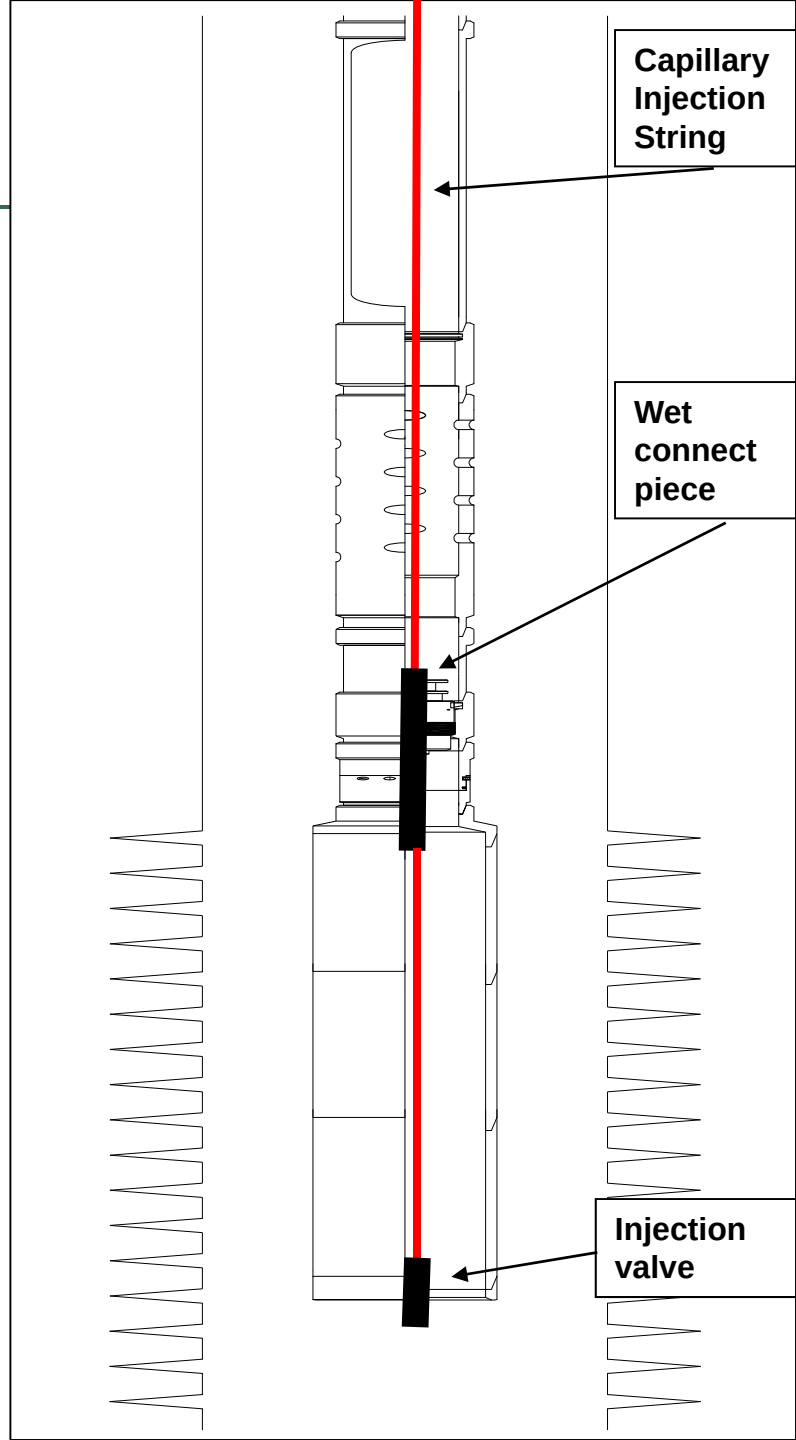
- Candidate wells are identified by:
  - Reviewing decline curve
  - Identifying the liquid loading point with existing flow areas and tubing placement
  - Identify produced fluids oil/water cut and ability to be foam lifted
- If flow area, surface tension and density reduction are not enough:
  - XtraLift- Extended Perforation Interval Gas Lift

iCVR Drawing

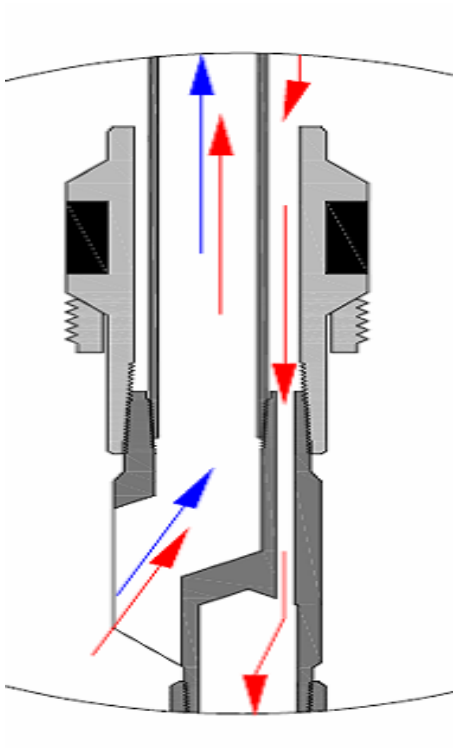
iCVR Advantages over CVR

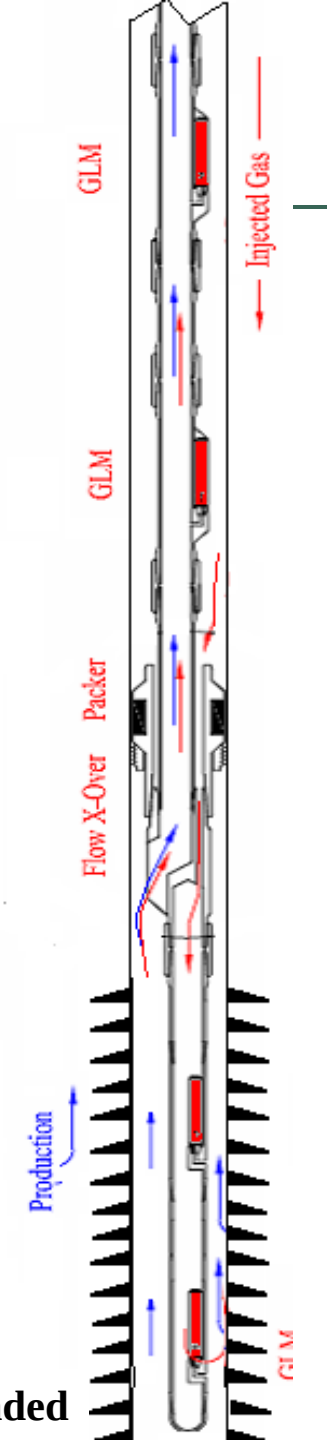
- **No Top Kill Required**
  - **Entire Assembly Can Be Snubbed In**
- **No Wellhead Modifications Needed**
- **No Stainless or Other Clamps Required**
- **Cap String Can Be Pulled If Plugged**

- **Loose the Ability to Run Plunger Lift without Pulling Cap String**



Xtra-Lift Extended Perforation Gas Lift



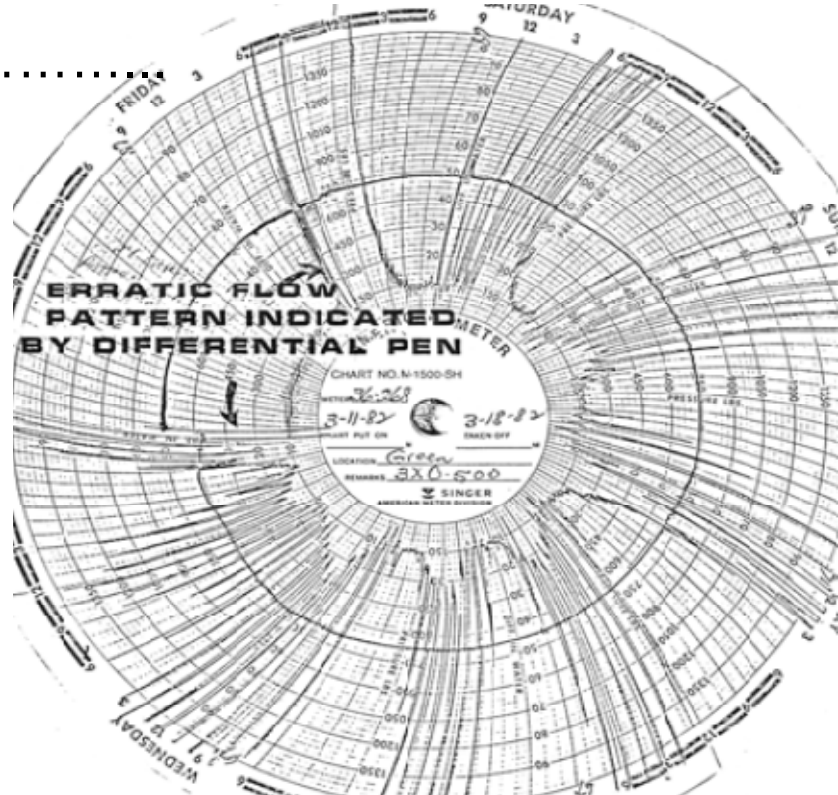


Optional ¼” Cap String Externally Banded

Deliquification Final Thoughts…..

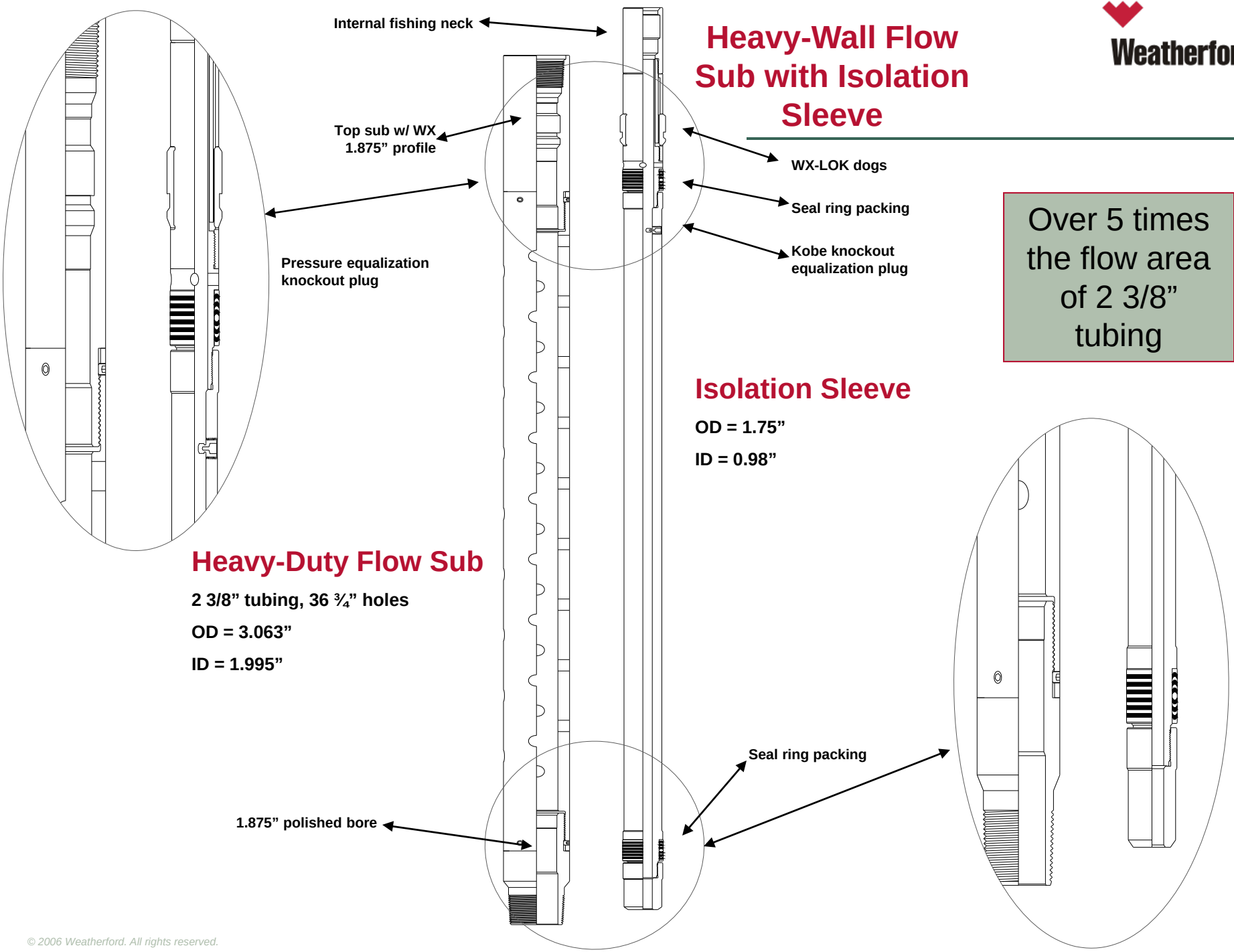
- Daily positive production from your well, does not mean that the well is “FLOWING”…….
  - **The Real Question is…..Are they UNLOADED?**
  - **Field Automation is a major technical advance. But you can miss the REST OF THE STORY……**
  - **Daily Automation Gas Rate = 200mcf/d….Is that all it can make?**
- Gas wells do not get stronger over time……..
- Proactive Solutions
- Use the Tools You Have Been Given
- Soap Sticks Work…..

  …….**ONLY** When **YOU** Work!!!
- **Do Not Hesitate to Contact Weatherford for Assistance!!!**



Questions?

Heavy-Wall Flow Sub with Isolation Sleeve



Over 5 times the flow area of 2 3/8" tubing

Isolation Sleeve

OD = 1.75"

ID = 0.98"

Heavy-Duty Flow Sub

2 3/8" tubing, 36 ¾" holes

OD = 3.063"

ID = 1.995"

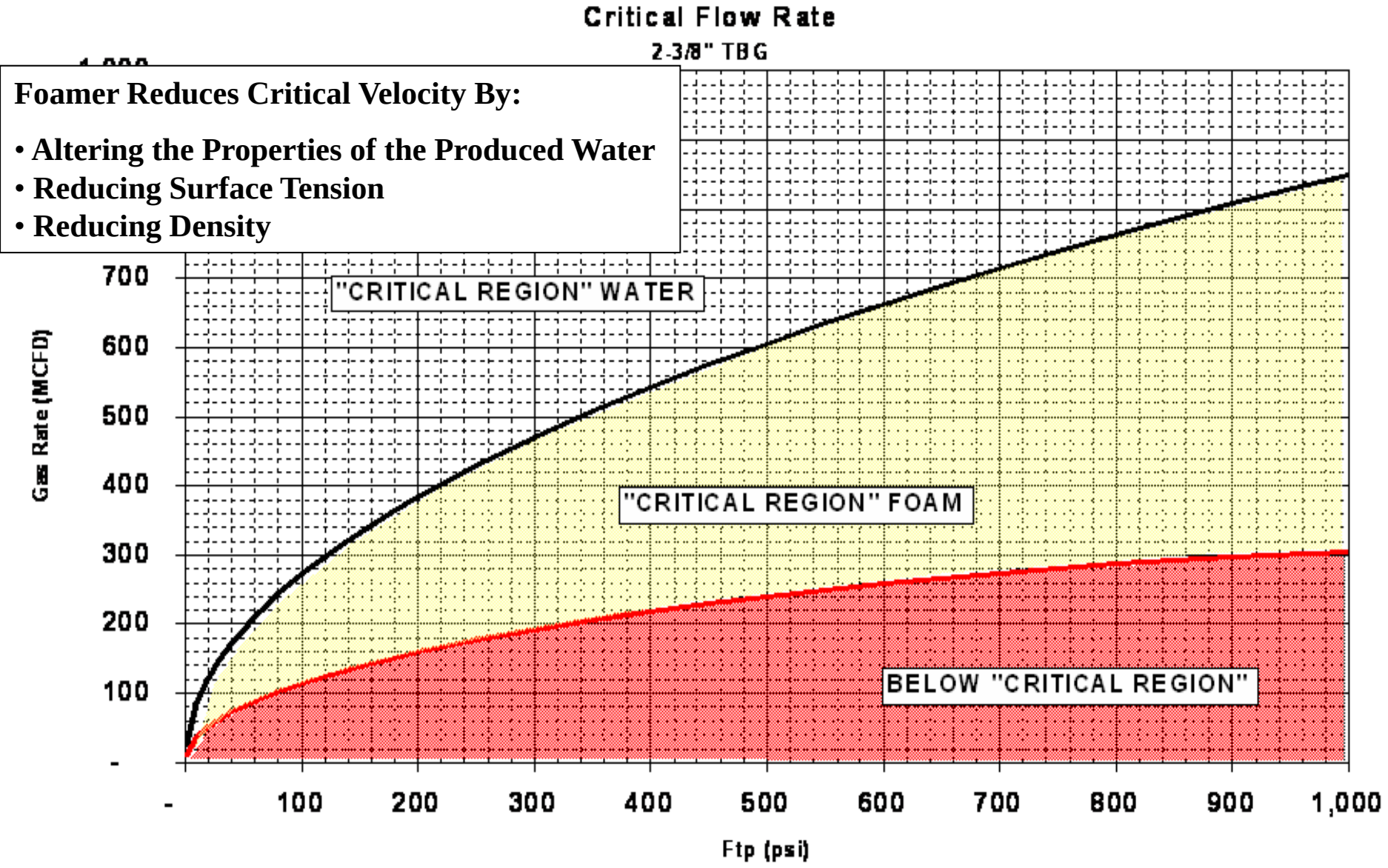
Adding Foamer

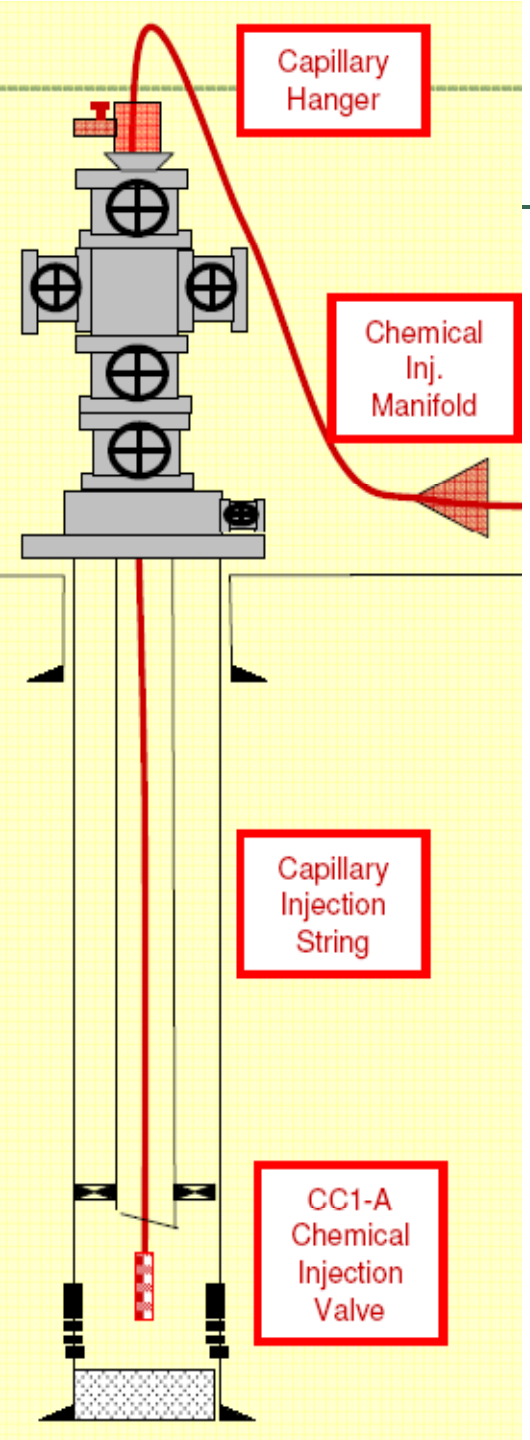
- Reduces surface tension and density of the produced water.
- Reduces the required gas velocity needed to lift water.
- Most common means of treating with soap:
  - Soap Sticks – short term impact- good test
  - Batch Treatments – short term impact- good test
  - Continuous Backside Injection
    - Needs Packerless completion
    - Only effective to the end of the production tubing
  - Capillary Injection – Continuous Pin Point Injection

Foam Assisted Critical Flow Rates – +/- 2/3 Reduction

Foamer Reduces Critical Velocity By:

- **Altering the Properties of the Produced Water**
- **Reducing Surface Tension**
- **Reducing Density**





Capillary Injection System Overview

Gas Well Applications

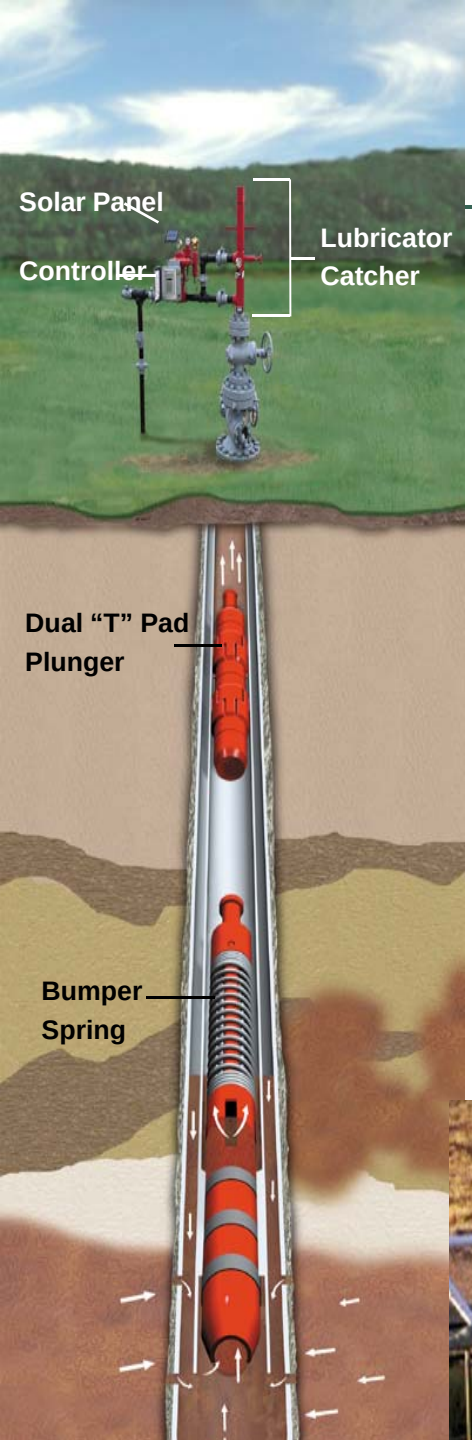
- Chemical Foamer Delivery System
- Foamer Reduces Water Surface Tension/Density
- 50% to 66% Reduction in Critical Velocity
- Surface Control Rate of Injection
- Combination Chemical Options – Foamer/Inhibitors

Gas Well Challenges

- Oil / Water Cuts
- Soap Injection Volume
- Capillary Injection String Plugging
- Metallurgy Selection

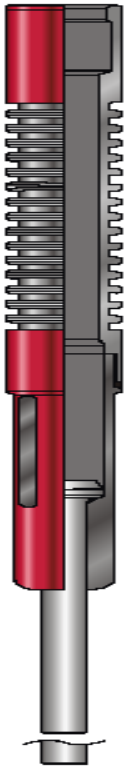
Our Heritage:
Built for Purpose/Built from Scratch

Plunger Lift System Overview



Gas Well Applications

- ❑ Usually Your First Choice
- ❑ Lowest Cost Solution
- ❑ Uses Well's Own Energy to Lift Liquids
- ❑ Specifically Designed for Dewatering Gas Wells
- ❑ Ideal for Isolated Areas



Gas Well Challenges

- ❑ Velocities – High or Low
- ❑ Gas Liquid Ratios – Must Have Gas….
- ❑ Optimization / Maintenance

Our Heritage:

McMurry Oil Tools