Ask Echometer Online Seminar – September 16, 2020

Addressing Incomplete Pump Fillage due to Gas Interference

Downhole Gas Separators Selection, Design, Performance

TOTAL ASSET MONITOR (TAM)

http://www.echometer.com/Software/Total-Asset-Monitor

"IMPROVED DOWNHOLE GAS SEPARATORS", McCoy, Podio, SWPSC 1998

"Gas Separator Selection and Performance", McCoy, Rowlan, Ellithorp, Podio, SWPSC 2017

"The Three Causes of Incomplete Pump Fillage and How to diagnose them correctly from Dynamometer and Fluid Level Surveys", McCoy, Rowlan, Podio SWPSC 2010

"The Use of Polished Rod Velocity and MPRL/PPRL Ratio as an Indicator of Failure Frequency", Gault, Lea, Rowlan SWPSC 2018

Presenters: O. Lynn Rowlan

Q & A: Gustavo Fernandez and Echometer Engineering and Support

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Download the Session 18 PDF Bundle and TAM Example Data from

https://echometer.com/Support/AskEchometer

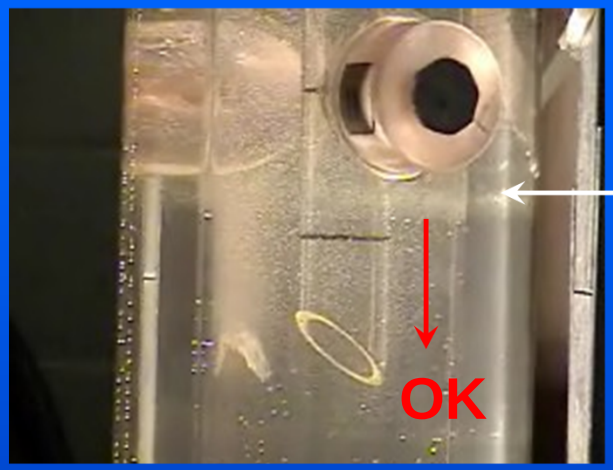
Gas Interference in Sucker Rod Pumps

- Many sucker rod lifted wells are currently operating at low efficiency because the installed downhole gas separator is inefficient.
- Major operational problems are encountered in producing Sucker Rod Lifted when free gas is interfering with liquid filling the pump
- Gas interference results in 1) significant loss in liquid production, 2) reduced drawdown, 3) increased failures and 4) inefficiency
- Installing an incorrectly designed/sized gas separator is the most common problem.
- When gas interference is present, expect increased rod-on-tubing wear (holes in tubing) ~ due to compressing free gas inside the pump to open the traveling valve.

SWPSC_2018_SRLift_Indicator of Failure Frequency.pdf

Liquid Velocity Should be Less Than ~6”/sec Bubble Rise Velocity from Laboratory Testing

Effect of Liquid Velocity



5 inch/sec

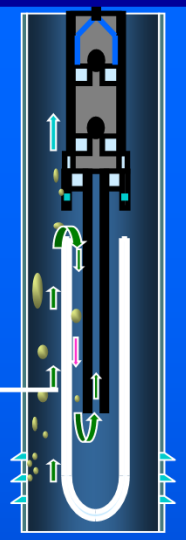
243 BPD

6 inch/sec

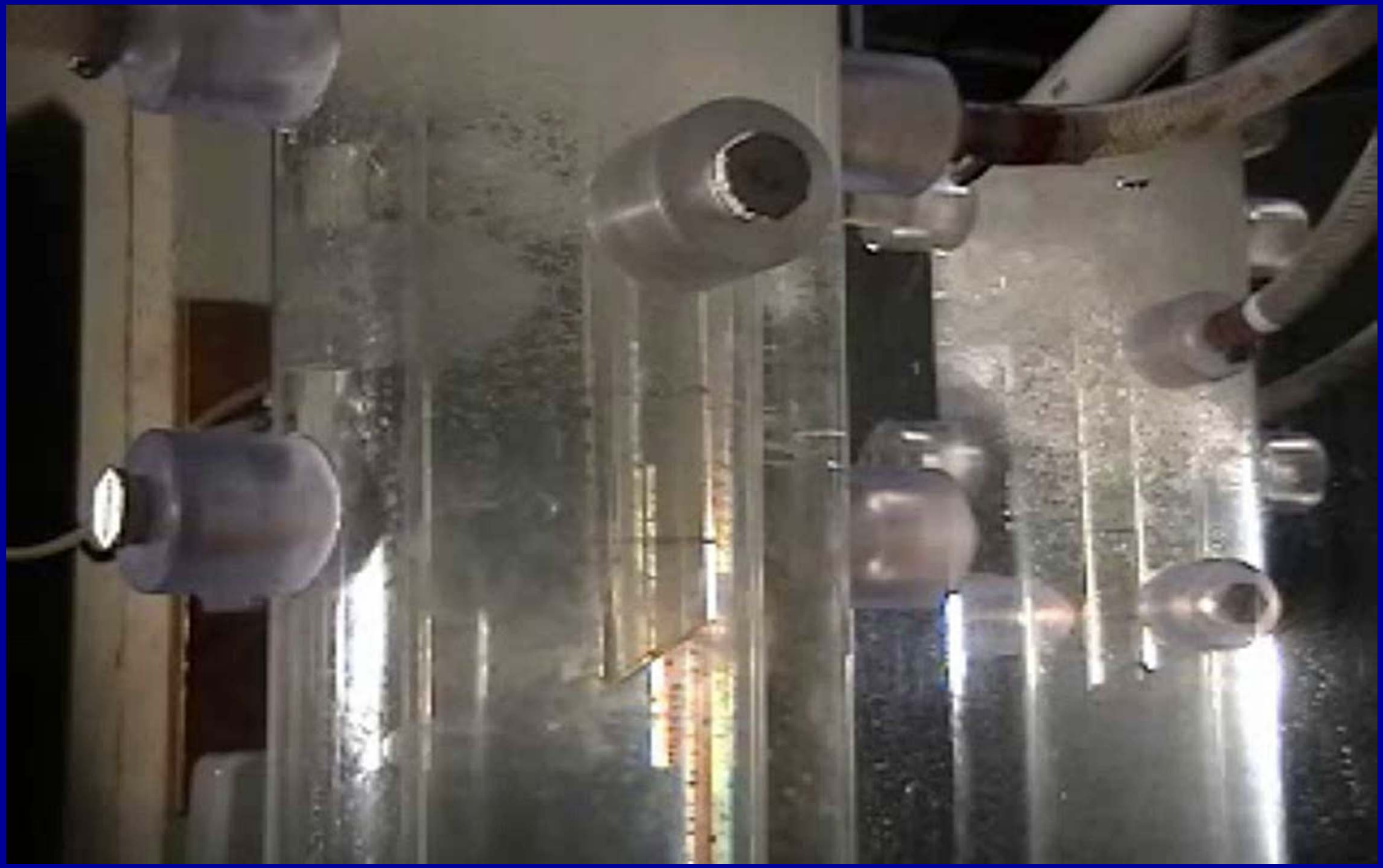
275 BPD

9 inch/sec

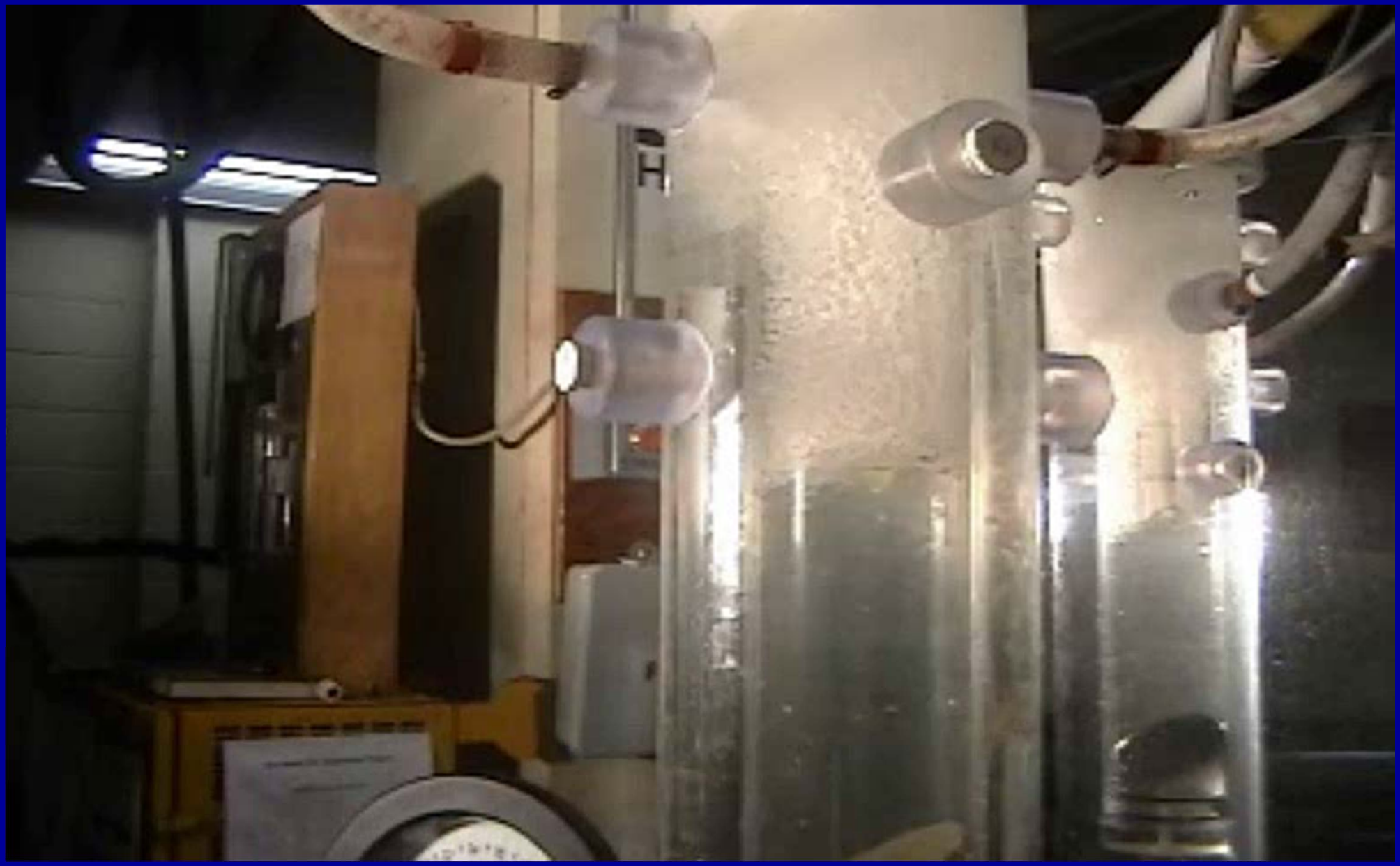
420 BPD



Separator OK Downward Flow rate 243 BPD 5 inches /Second

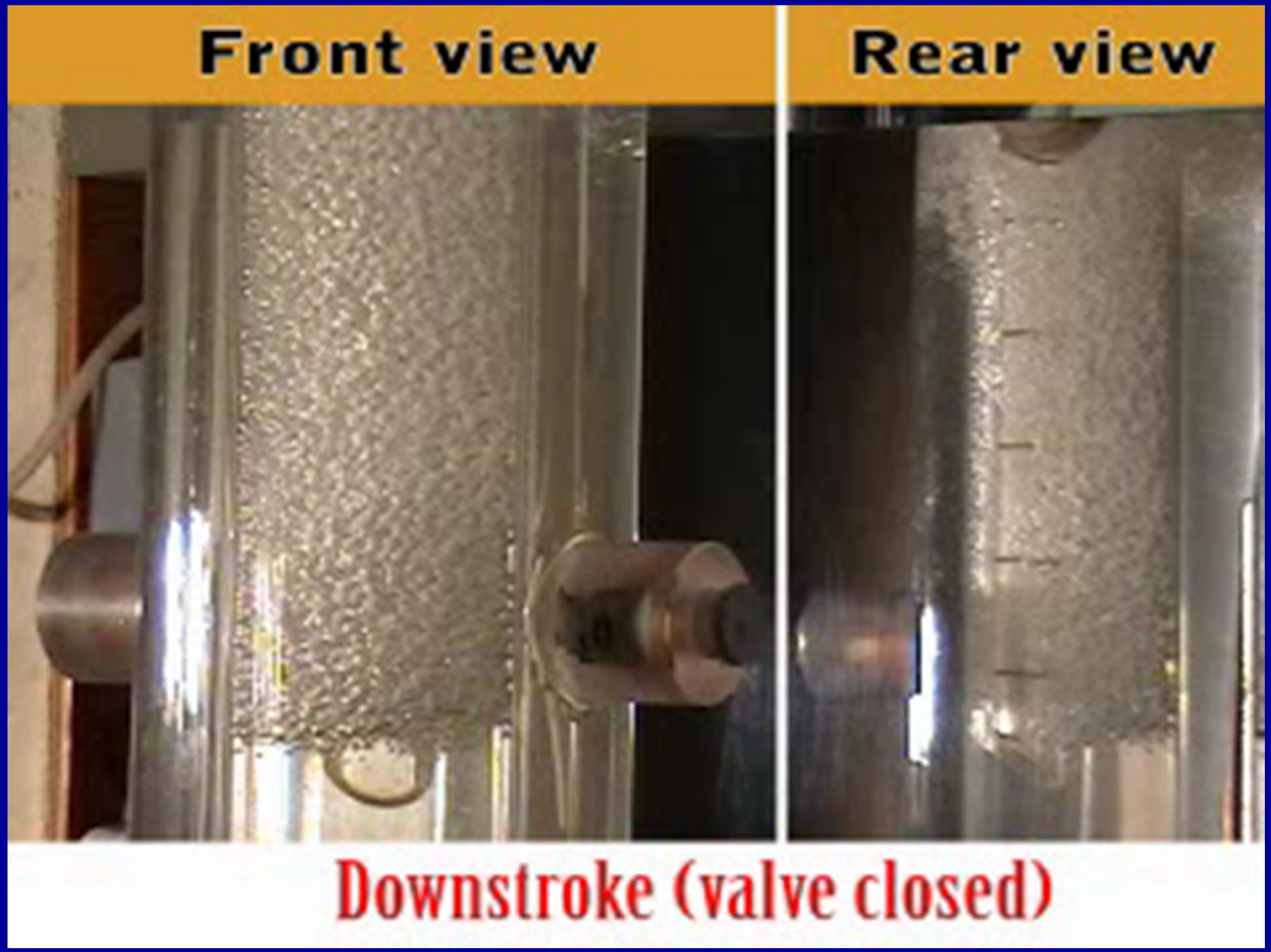


Separator Fails Due Downward 420 BPD Flow at Velocity of 9 inches /Second



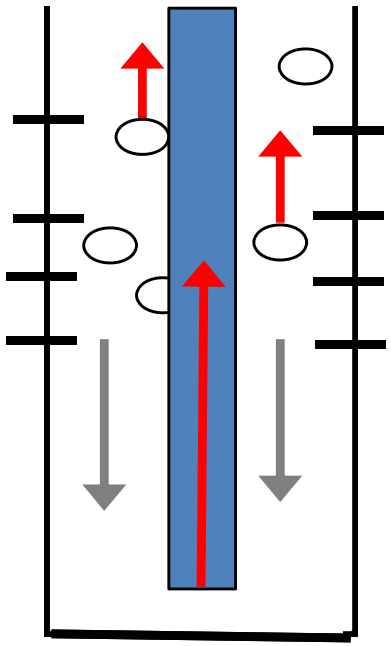
Large and Small Bubble in Casing

Gas Bubbles Must Exit Gas Separator When SV Ball on Seat During SR Pumping Cycle



Downhole Gas Separator Principle of Operation

Gas Separator Liquid Capacity is Based on the Following Principle:



The outer pipe can be the casing or the outer barrel of a gas separator. The inner tube is the inlet to the pump.

1/4 INCH DIAMETER GAS BUBBLES FLOW UPWARD IN OIL OR WATER AT A RATE OF APPROXIMATELY 6 INCHES PER SECOND. THUS, GAS BUBBLES WILL BE RELEASED FROM A LIQUID COLUMN IF THE DOWNWARD LIQUID VELOCITY IS LESS THAN 6 INCHES PER SECOND.

A LIQUID COLUMN HAVING AN AREA OF 1 SQUARE INCH TRAVELLING AT 6 INCHES PER SECOND IS A FLOW RATE OF 50 BPD.

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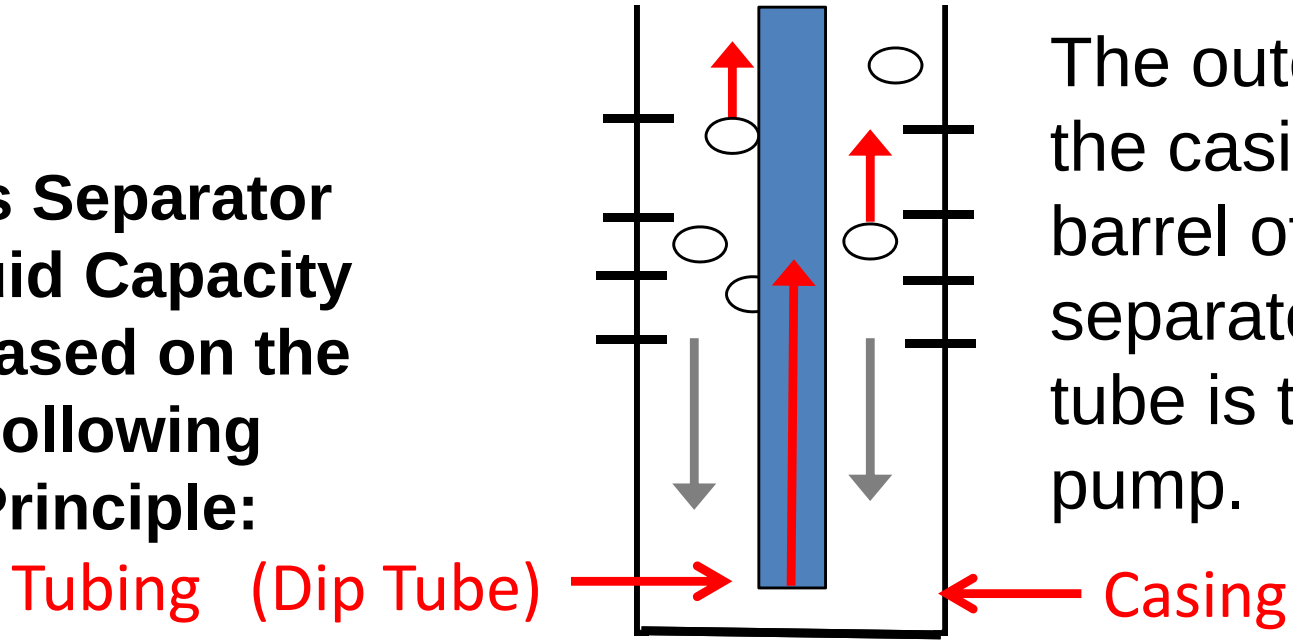

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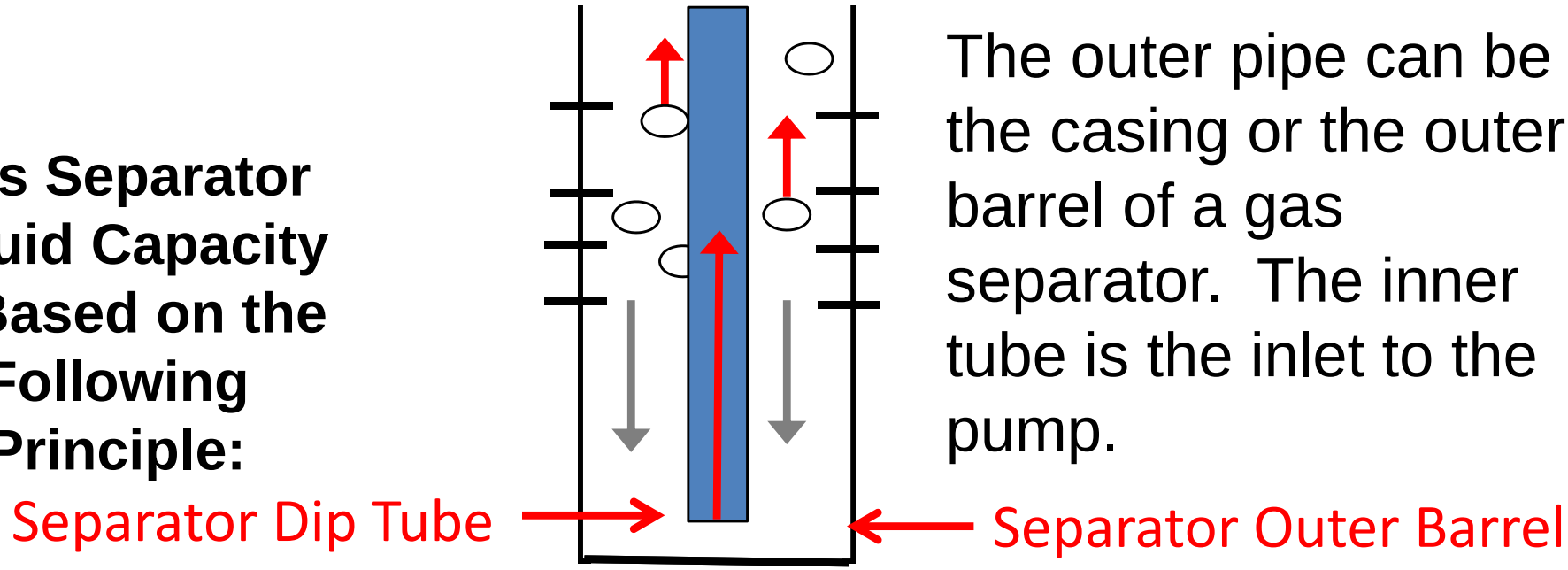

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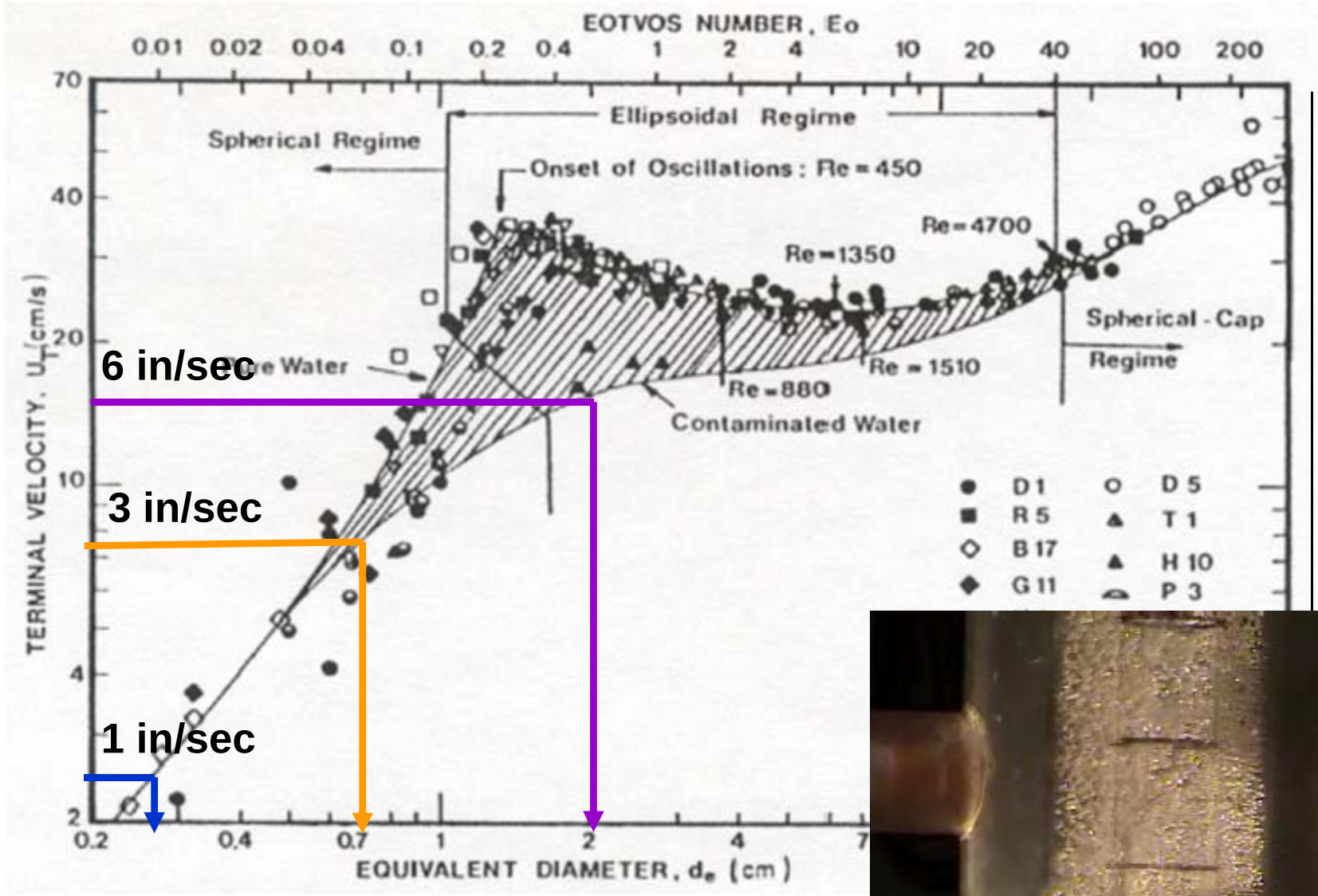
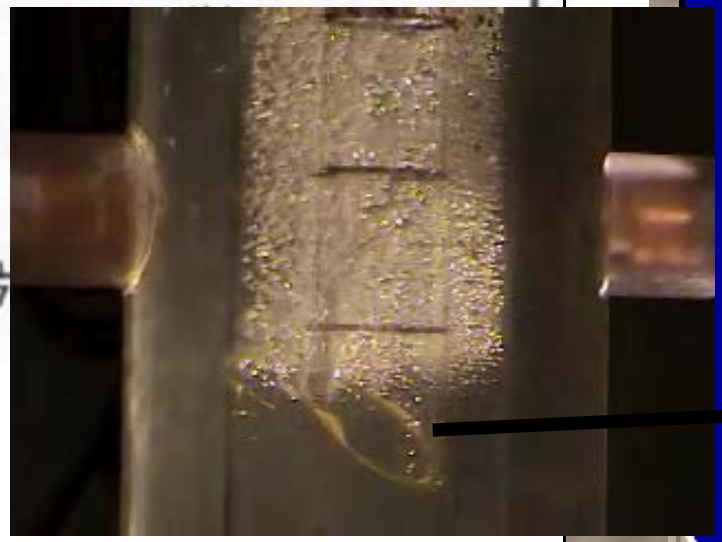
Gas Bubble Size Impacts Rise Velocity

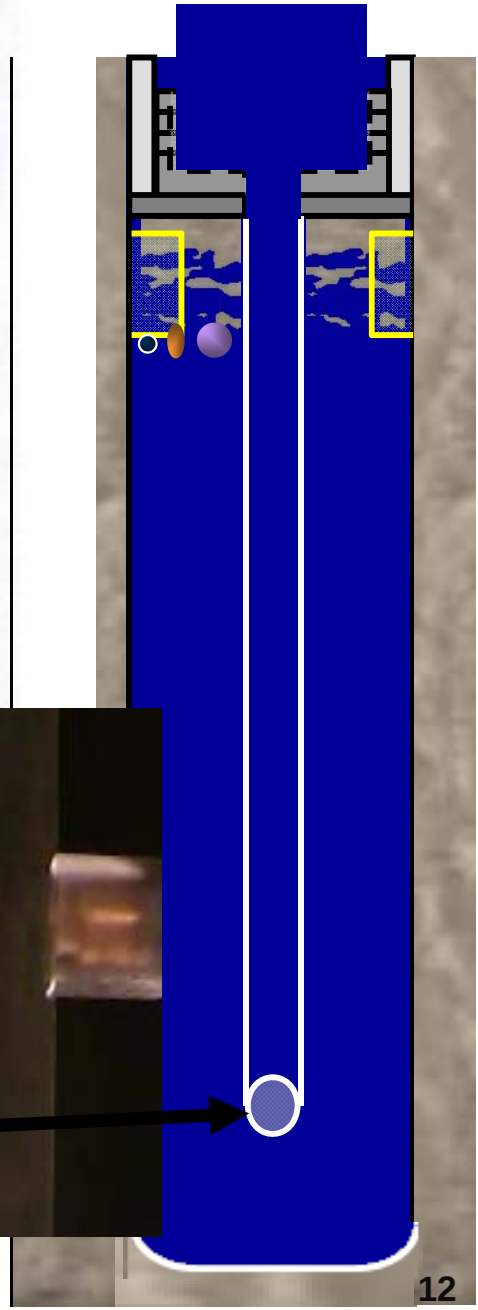
The gas bubble rise rate in a more dense liquid depends upon its size and other factors. The larger the gas bubble, the faster the bubble rises. From field data and lab data, the measured "average" gas bubble rise velocity at downhole pump conditions is accepted to be 6 inches per second and the size is approximately 1/8th to ¼ inch in diameter.

The gas separator simulation software will allow determination of "average" gas bubble rise velocity in a variety of gas separator configurations and sizes using actual field data.

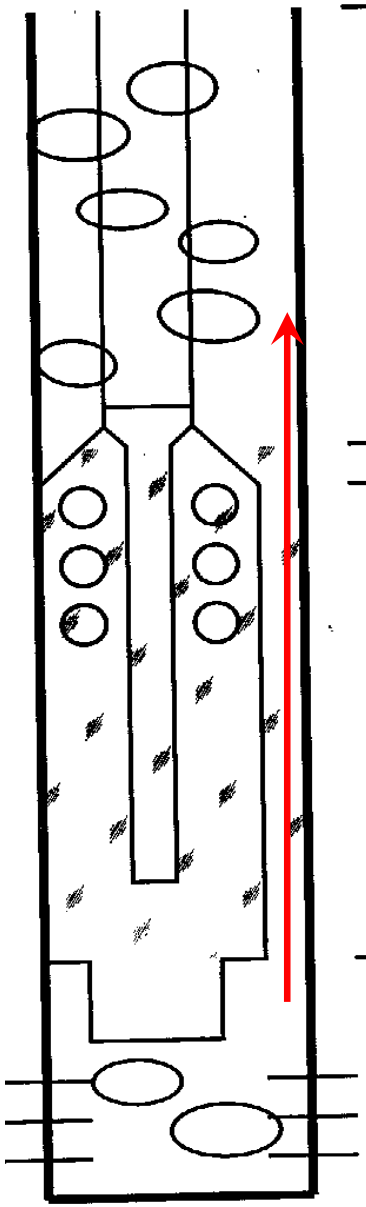
Bubble Size Impacts Rise Velocity







ANNULAR GAS Velocity Causes a Problem if MIST FLOW is Created

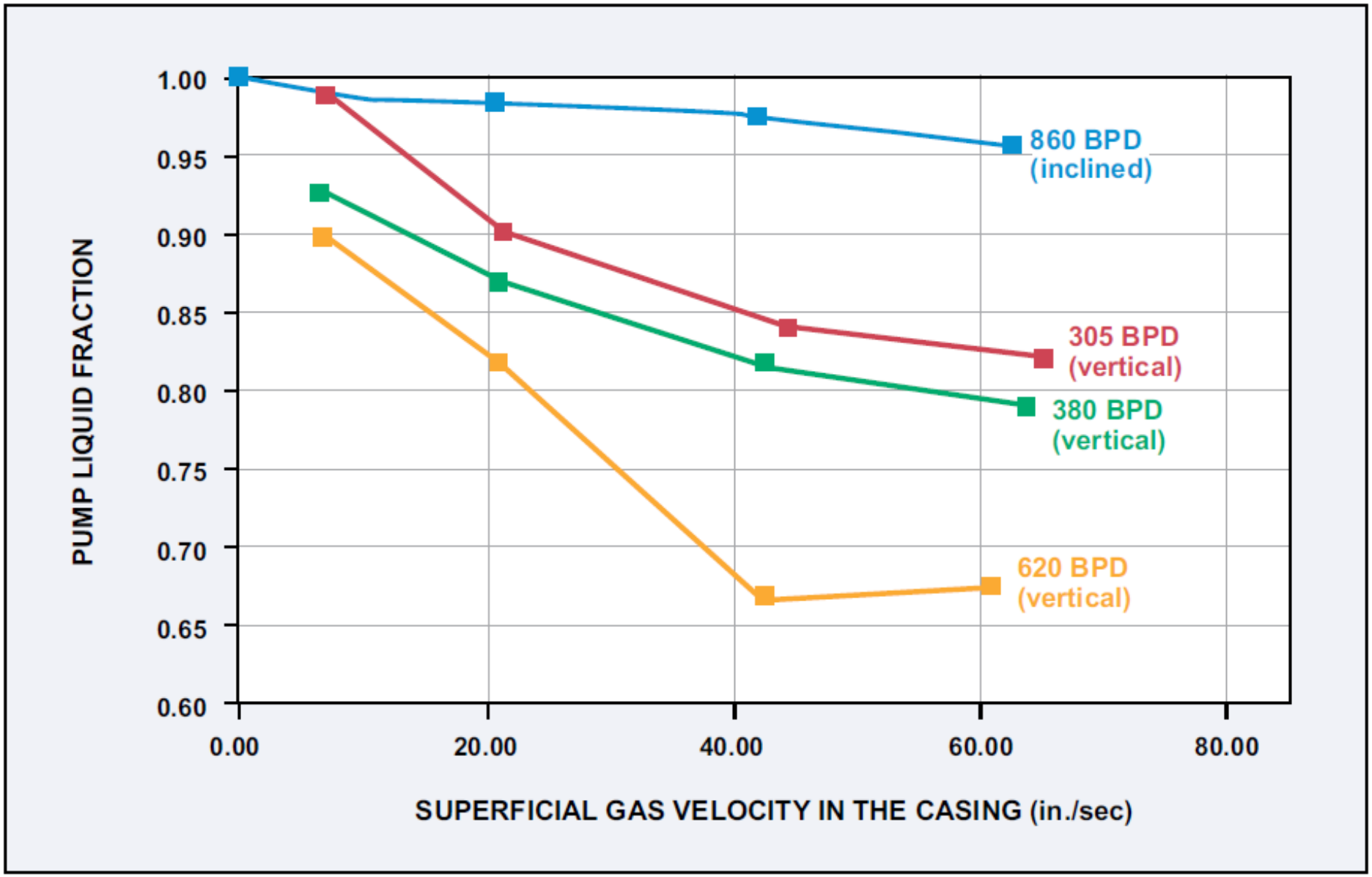


FREE GAS BUBBLES MOVE UPWARD THROUGH THE OIL THAT REMAINS IN THE CASING ANNULUS AND THE ACCUMULATION OF OIL IN THE CASING ANNULUS CAUSES REDUCED FLOW FROM THE FORMATION

MIST FLOW
HIGH GAS FLOW RATES EXCEEDING 10 FEET/SEC IN THE REDUCED AREA BETWEEN THE CASING AND THE OVERSIZE GAS SEPARATOR CAUSE THE LIQUID TO BREAK INTO SMALL DROPLETS THAT ARE CARRIED WITH THE GAS. THE LIQUID DOES NOT FLOW INTO THE GAS SEPARATOR

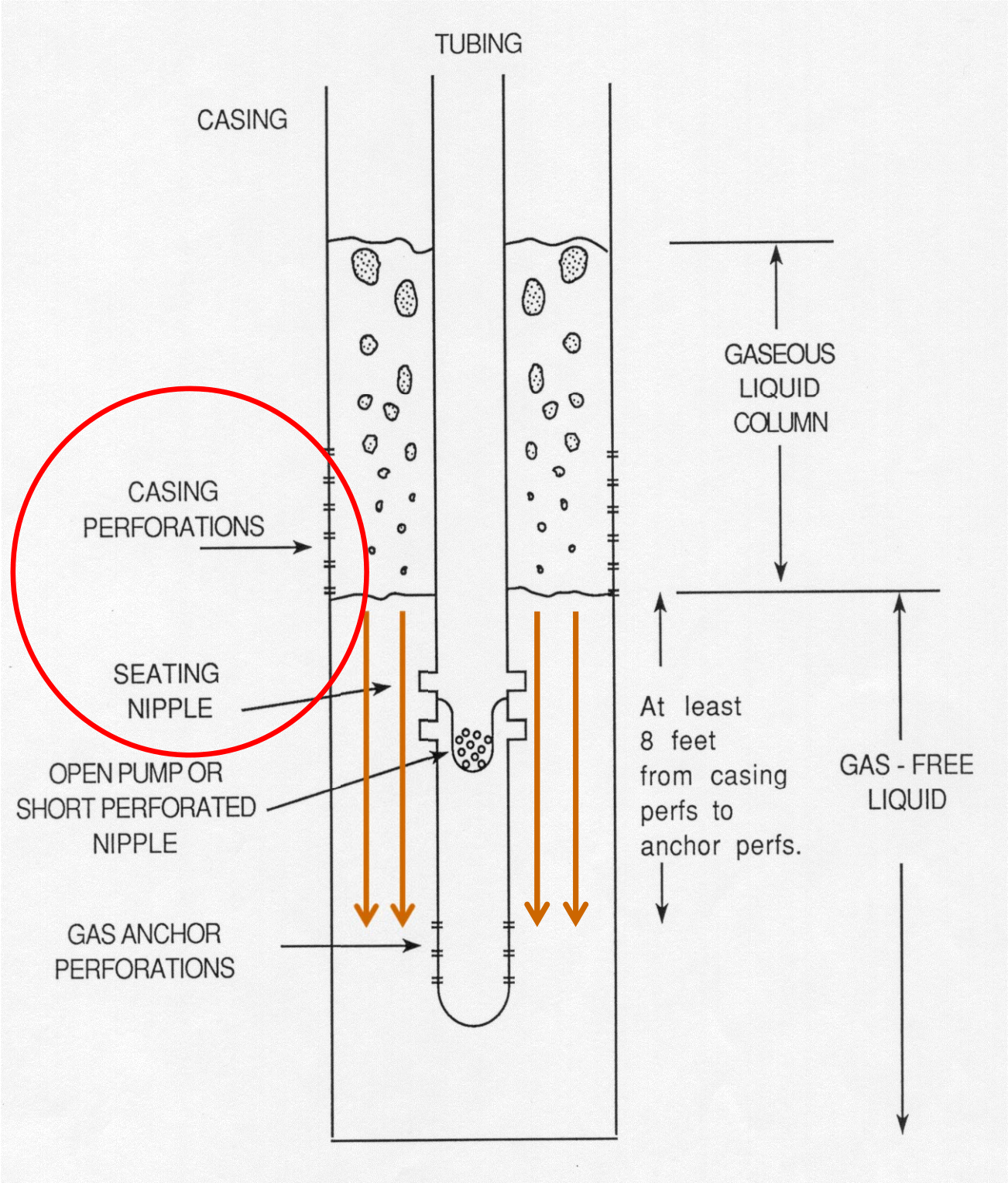
HIGHER BOTTOMHOLE PRESSURES REDUCE THE GAS FLOW VELOCITY

Setting a 10 ft/sec Gas Velocity Limit Insures that Annular Gas Flow Does NOT Cause annular or mist flow



Reference: R. Bohorquez, V. Ananaba, O. Alabi, A. L. Podio, O. Lisigurski, and M. Guzman, "Laboratory Testing of Downhole Gas Separators," SPE production and Operations Journal, November 2009)

Natural Gas Separator



The most efficient downhole gas separators locate the pump intake below the lowest gas entry point.

Gas is not pulled down to the pump perforations unless the liquid velocity is greater than 6 inches per second.

Maximum capacity is obtained using casing annulus.

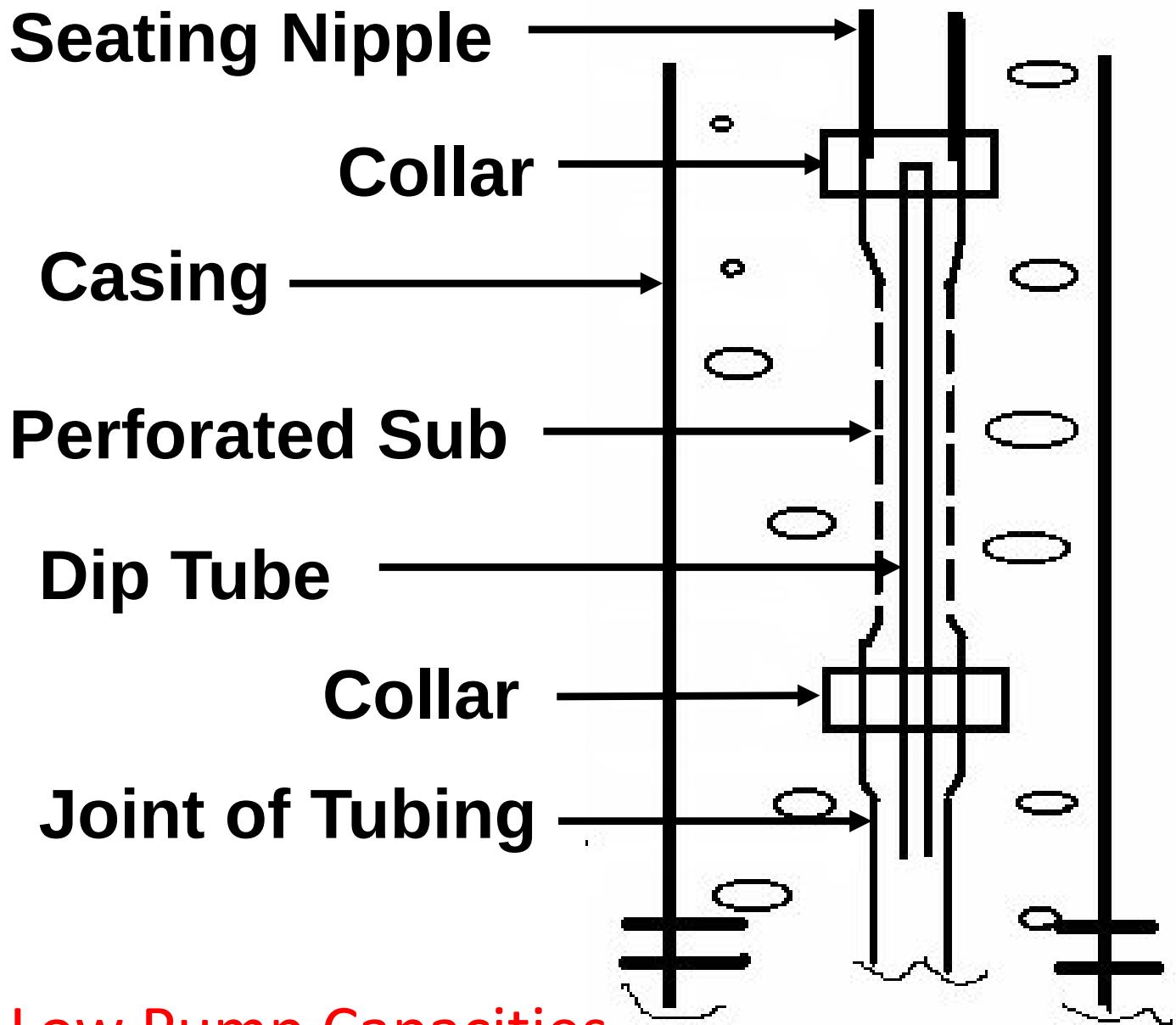
Natural Gas Separator Liquid Capacity

Casing Size Inches	Tubing Size Inches	Capacity BPD
7	2 7/8	1200
5.5	2 7/8	580
4.5	2 3/8	420

"Poor-Boy" Gas Separator is Low Capacity

Limited Flow Area and Small Holes

Tubing Collars prevent perforated sub from laying against casing wall where liquid accumulates



Acceptable for Low Pump Capacities

“Poor Boy” Gas Separator Liquid Capacity

GAS SEPARATOR CAPACITY TABLE
SEPARATOR ABOVE FLUID ENTRY ZONE

Outer Barrel Description and Size, Inch	Dip Tube Size Inch	Annulus Area SQ Inch	Liquid Capacity BPD
3 1/2 Perforated Tubing Sub	1.250	4.87	260
2 7/8 Perforated Tubing Sub	1.000	3.32	177
2 7/8 Perforated Tubing Sub	1.250	2.52	134
2 3/8 Perforated Tubing Sub	0.750	2.26	121
2 3/8 Perforated Tubing Sub	1.000	1.77	94
2 3/8 Perforated Tubing Sub	1.250	0.96	51
2 3/8 Perf Tub Sub & 1.5" Pump	1.760	0.69	37

Improved Collar Size Gas Separators SWPSC 1998.pdf

Gas Separator Simulation Software SWPSC 2014.pdf

Maximum Capacity Behavior

Run a 2 3/8 Poor boy at 80 and 96 and 120 BPD Pump Capacity

((echometer)) Gas Separator Simulator

File

(((ECHOMETER))) Gas Separator Simulator

Casing Size: 5.5" 14 lbs/ft (ID 5.012")

SEPARATOR PRESETS:

2 3/8" Poor Boy Separator

Separator OD:	2.375	in
Separator ID:	2	in
Dip Tube OD:	1.315	in
Dip Tube ID:	1.05	in
Net Dip Tube Length:	72	in

Based on Gas Bubble Rise Velocity and Strokes Per Min,
Minimum Effective Net Dip Tube Length is 37 in

Gas Bubble Rise Velocity:	6	in/sec
Strokes Per Min:	6	

Net Pump Displacement:	80	BPD
Max Separator Capacity:	96	BPD

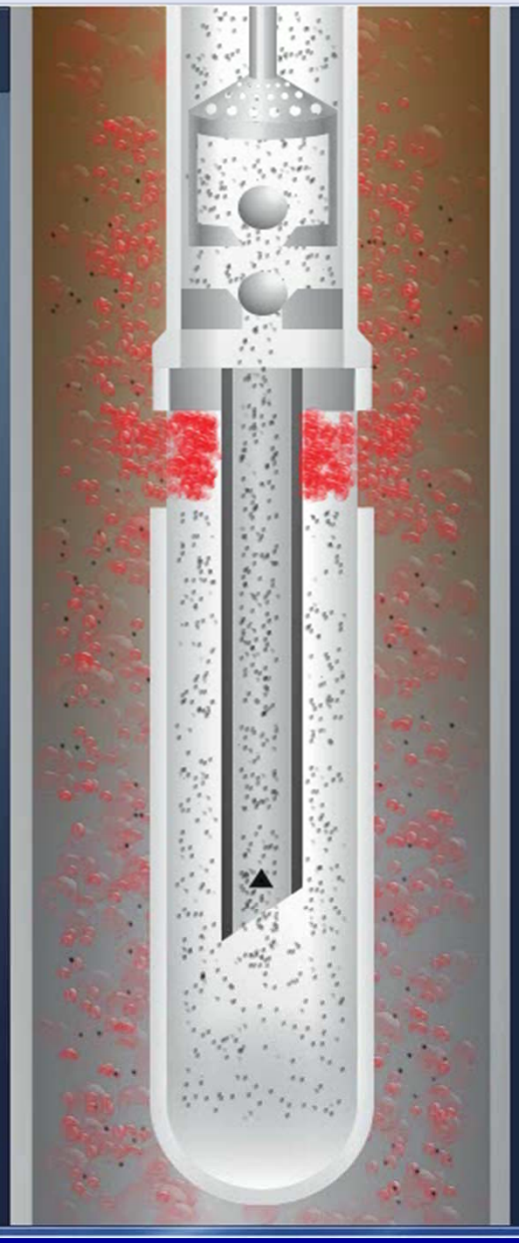
STOP

SHOW DIMENSIONS

SAVE AS PRESET

INFO

HELP



Modified Poor Boy Separators

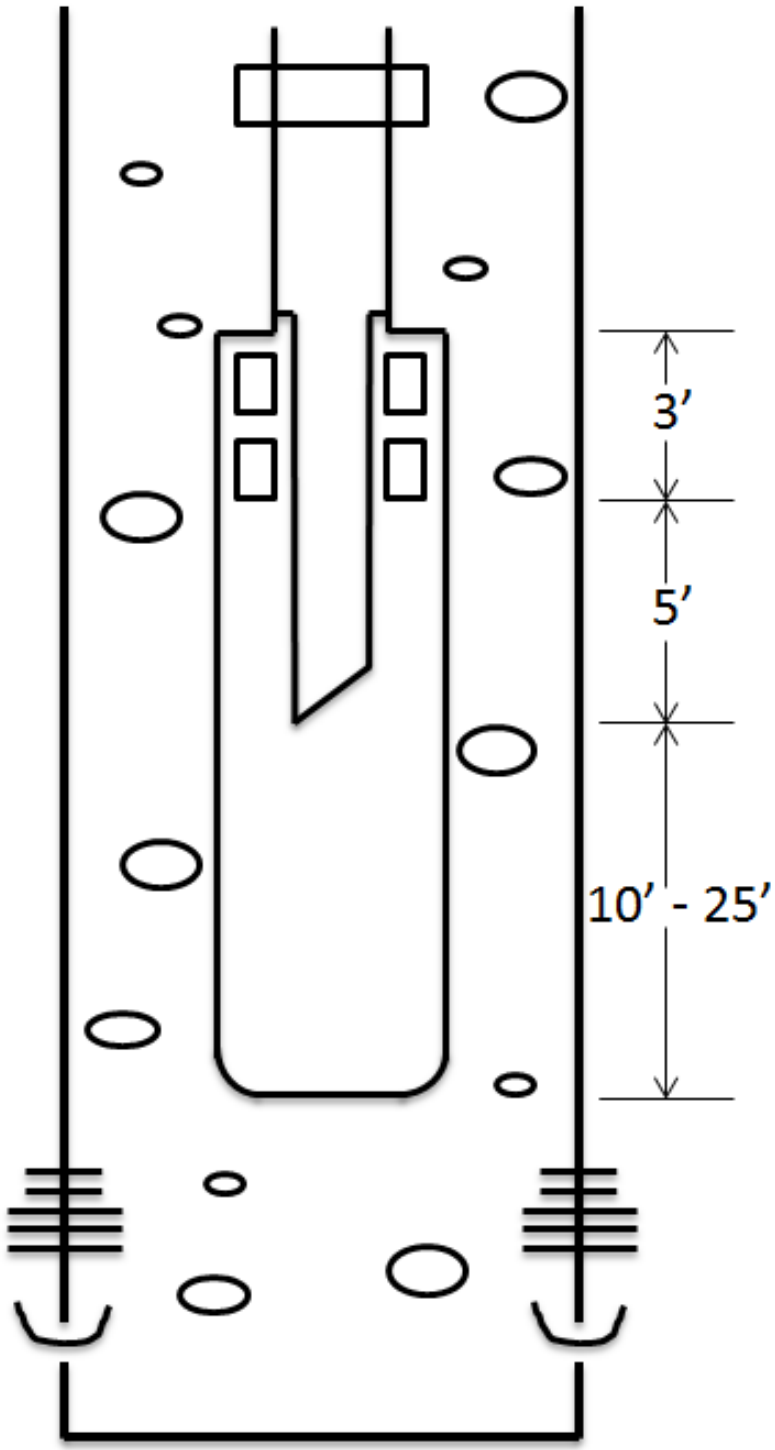
Outer barrel enlarged for greater liquid/gas separation capacity.

Space between the outer barrel and the casing should not result in Gas Flow greater than 10 ft/sec

Outer barrel ports should be machined so that the edges are smooth. Do not use a welding torch to cut the ports.

Dip tube should extend about 4 feet below the outer barrel perforations…Use Simulator to Determine Length.

Lower portion of the outer barrel is used for sand and debris collection…the bottom must be closed with orange peel or bull plug. Bull plug on the bottom allow a joint of tubing to be placed below the outer barrel for sand collection capacity…the bottom must be closed.



Collar Size Separator Increases Pump Fillage

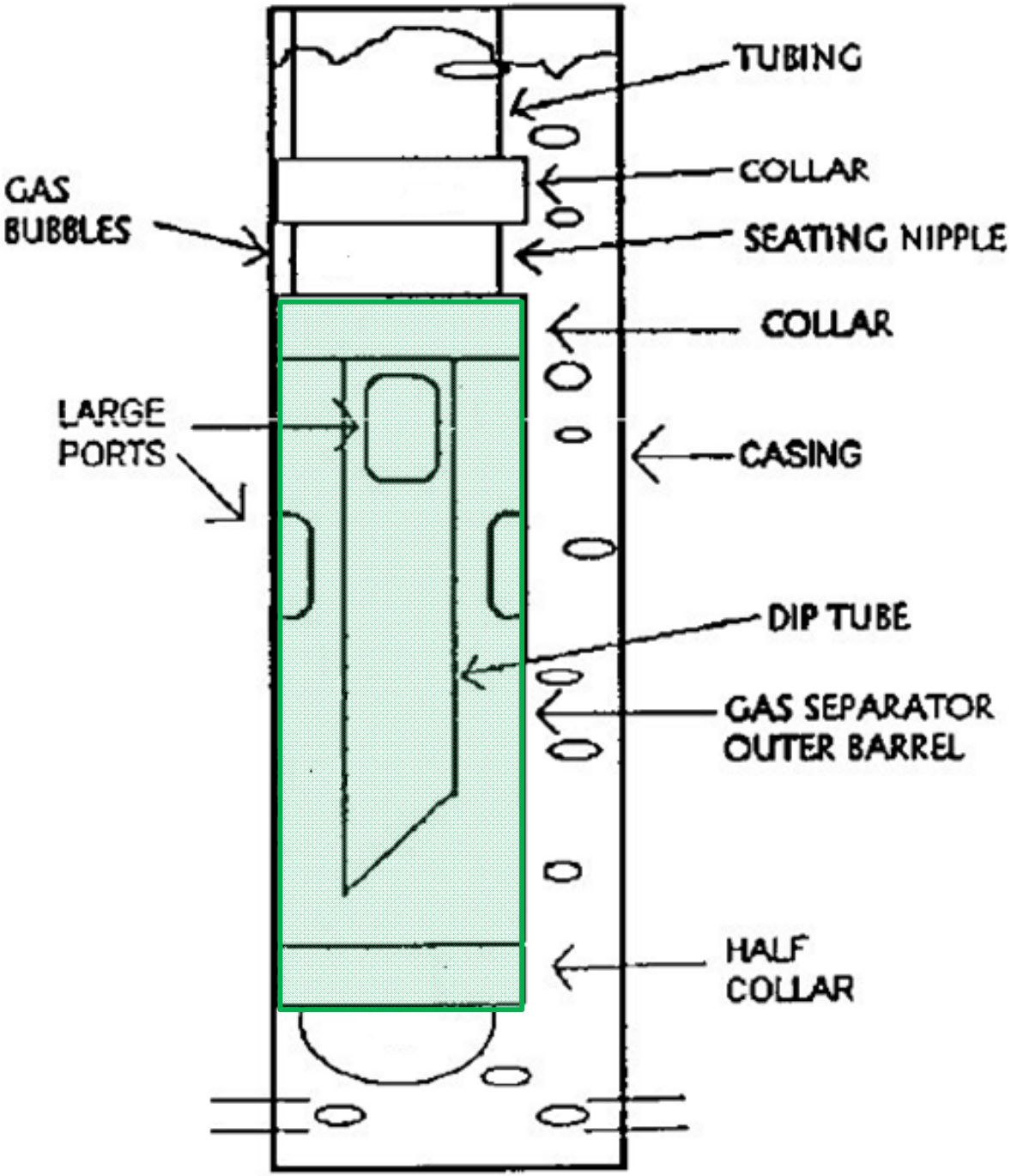


Fig. 5 Collar-Size Gas Separator in Casing

A good separator must balance annular flow area, separator flow area, dip tube diameter and pressure drop.

Outer barrel OD same as collar OD.

Thin wall outer barrel and short dip tube.

Large inlet ports distributed around outer barrel facilitate entry of liquid.

Offset against the casing wall.

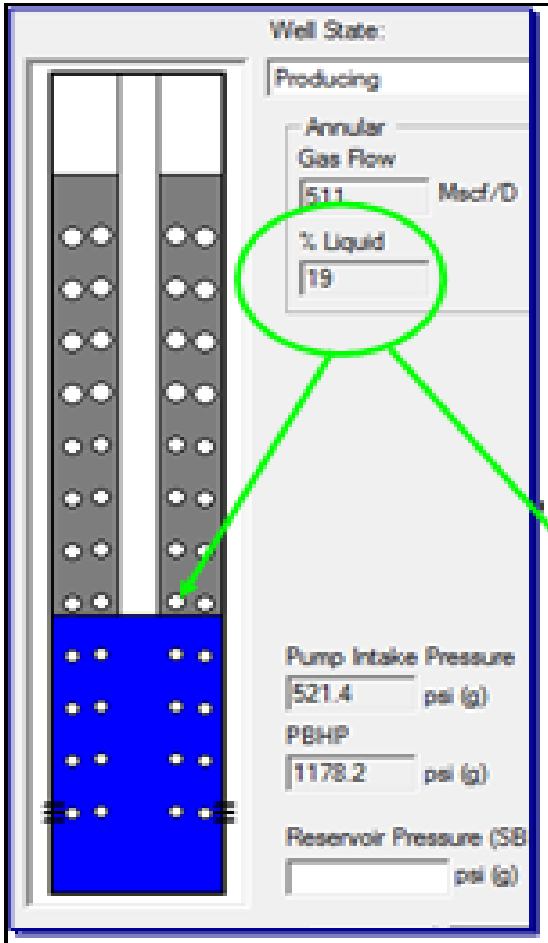
Collar Size Gas Separator Liquid Capacity

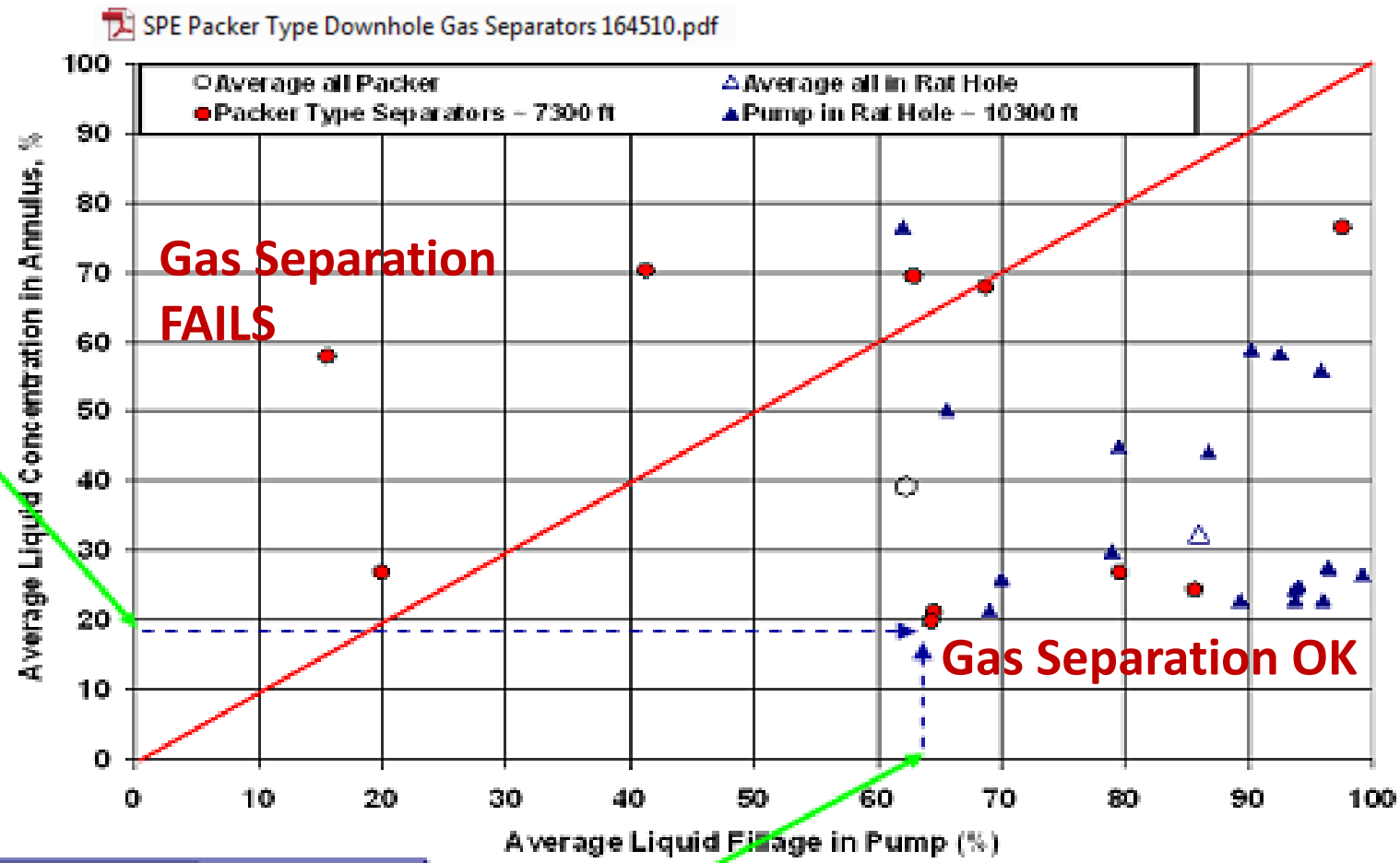
Tubing Size Inches	Outside Diameter Inches	Capacity BPD
2 3/8	3	275
2 7/8	3.75	443
3 ½	4.5	644
4	5	833
4 ½	5.5	1044

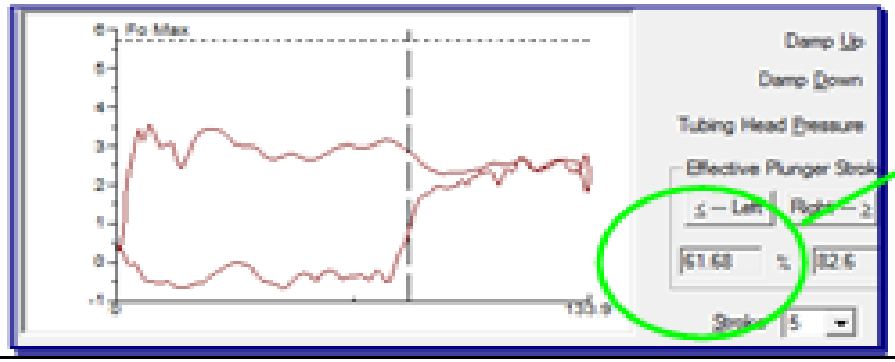
Efficiency of the Downhole Gas Separation Process

- Efficiency of the downhole gas separation process expressed by two different methods:
    1) Effective Pump Fillage % - EPF%
    2) Gas Separator Efficiency %.
- <u>Effective Pump Fillage %</u> represents the ratio of effective plunger travel divided by maximum plunger travel expressed as a percent.
- <u>Gas Separator Efficiency %</u> percentage of free gas at the pump intake pressure condition vented up the casing not entering the pump

Gas Separation FAILS if Pump EPF% Less than % Liquid in Annulus





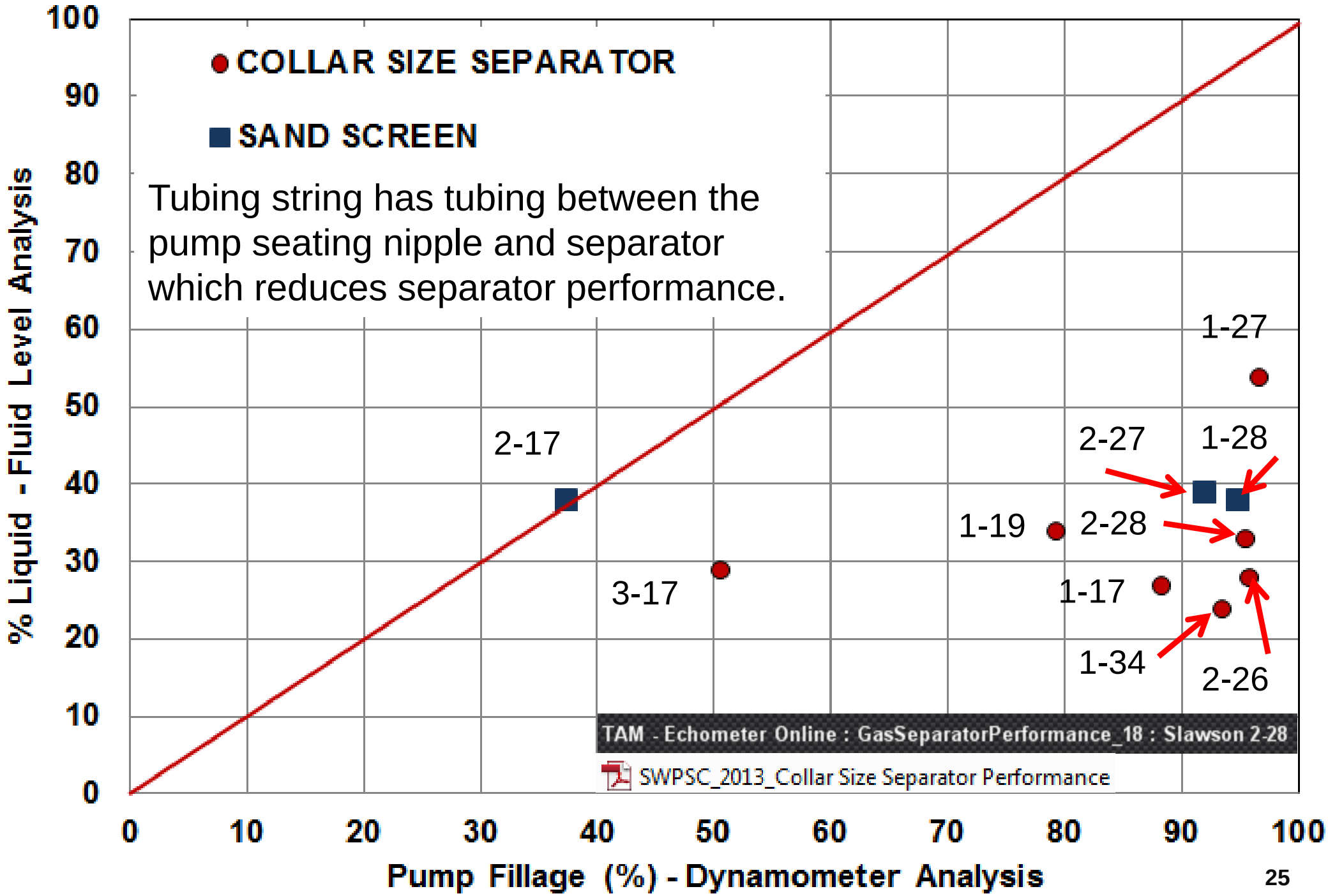


Optimizing Downhole Packer-type Separators SWPSC 2013.pdf

Casing Size Limits Gas Separation Maximum Capacity

Collar Size Gas Separator Performance

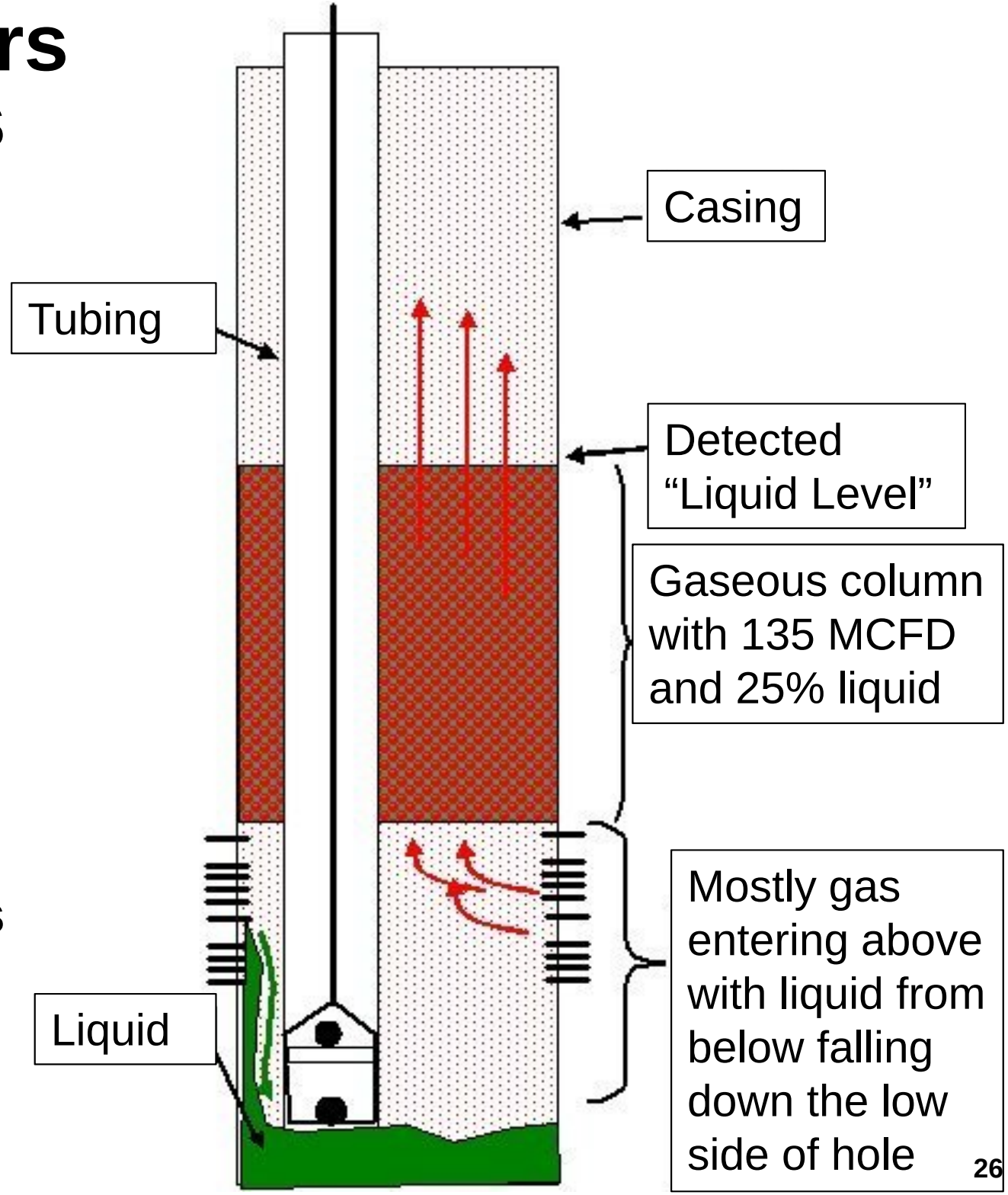
Slawson Exploration - North Dakota - Bakken Formation



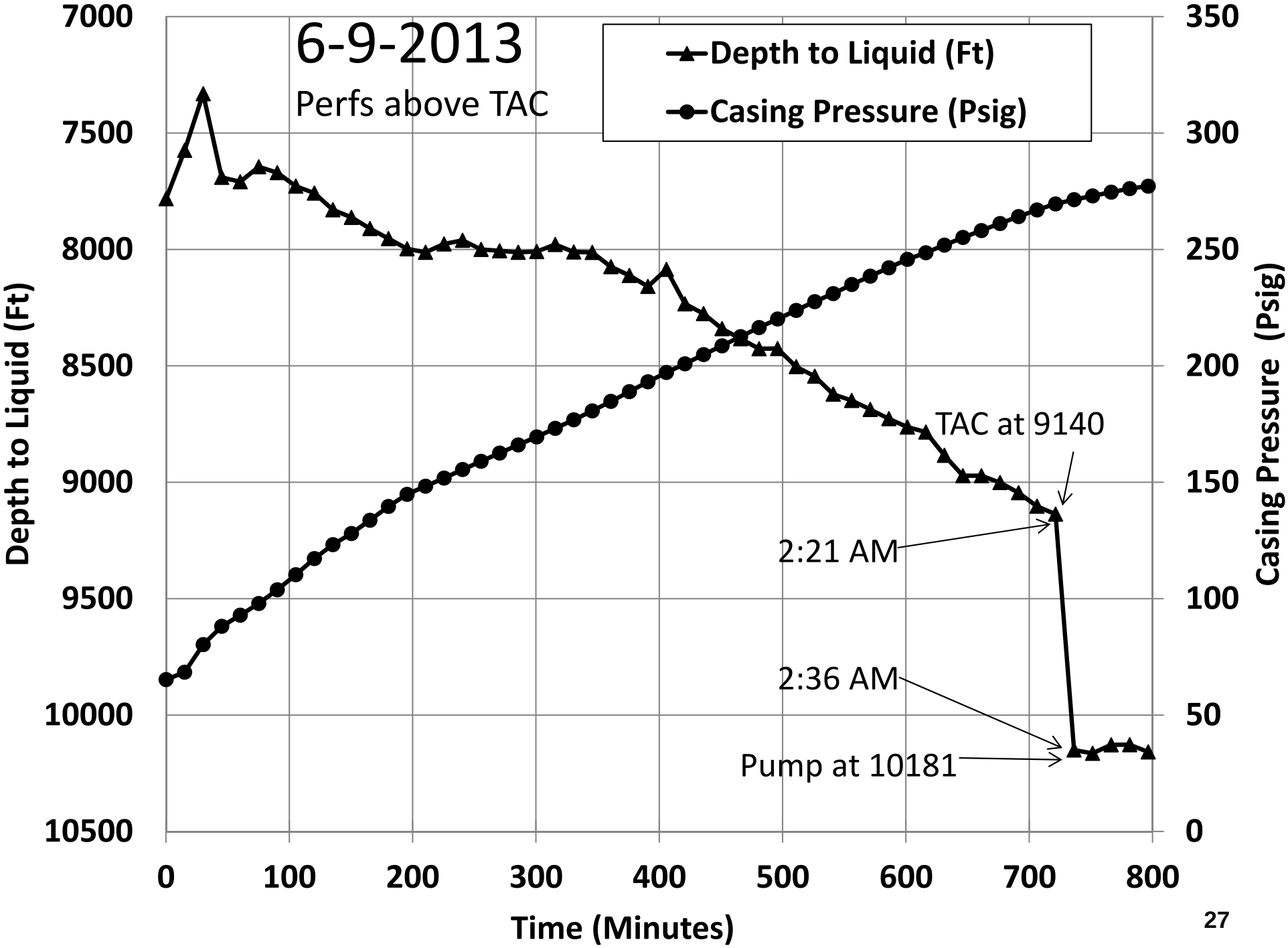
Tubing Anchors & Liner Tops

Tubing anchor with the gaseous fluid column combine to create a choke mechanism that regulates gas flowing up the casing annulus

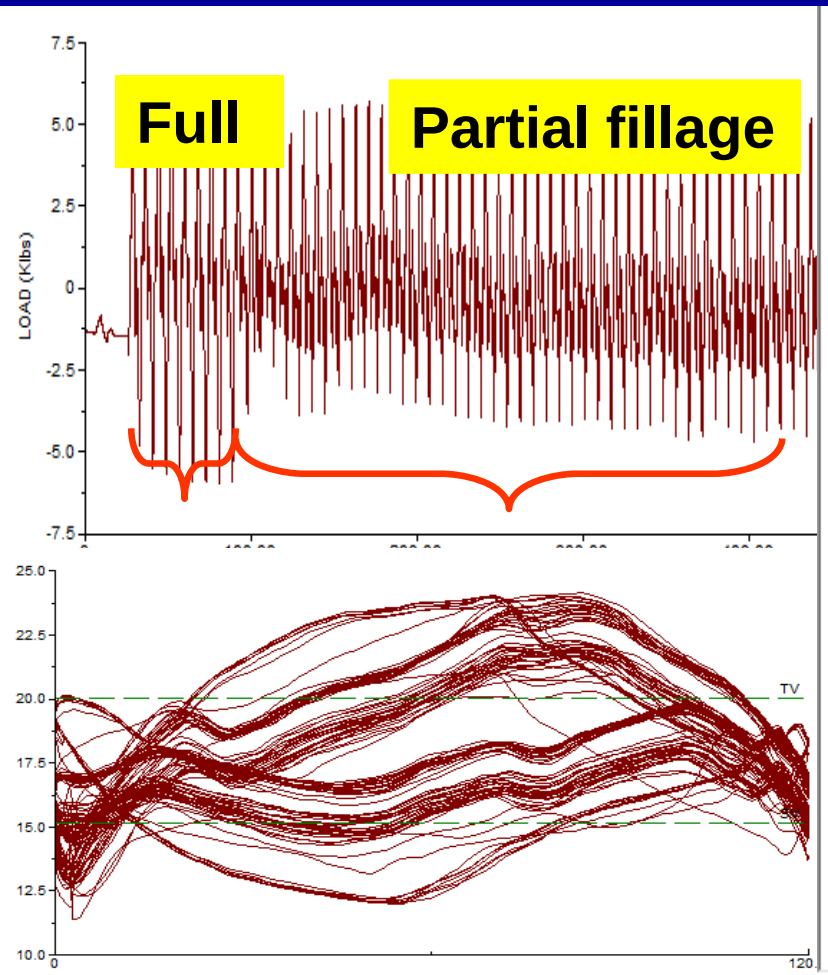
Gas Separation FAILS due to problem of TAC restricting annular gas flow causing pump filled with gas

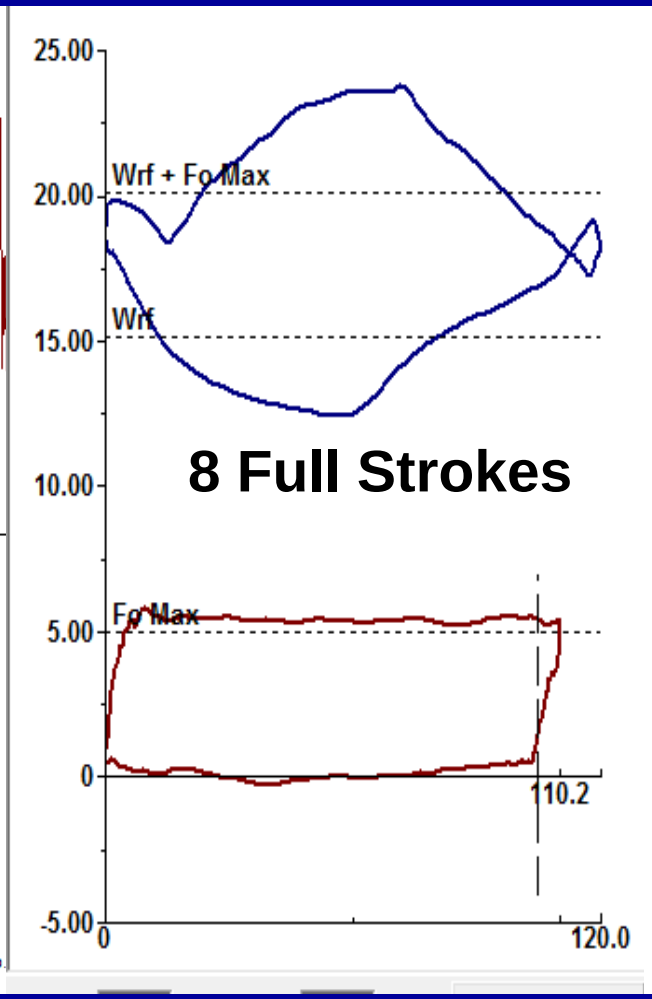


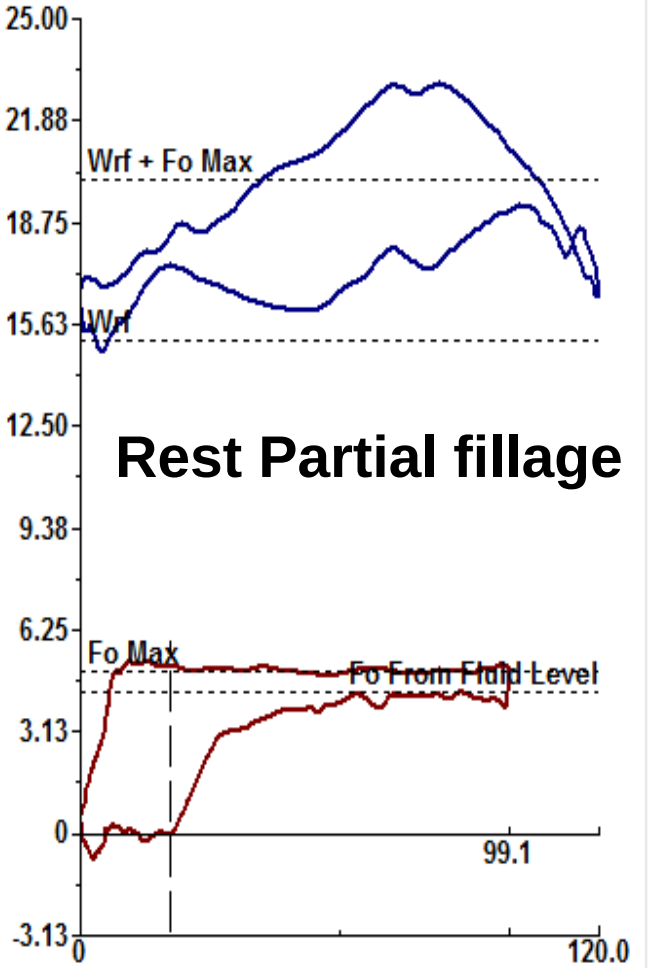
Fluid Level Depression Test Lupin 3104



High Capacity 420 BPD Pump in the Rat Hole FAILS TAC restricts annular gas flow







Dynamometer Test After 10 Minute Shut down

Tubing Anchors Can Restrict Production Rates and Pump Fillage SWPSC 2014.pdf

TAM - Echometer Online : GasSeparatorPerformance_18 : 3104

Heavy-Wall Gas Separator

This heavy-wall separator can be run above a TAC so that the collection of free gas below the TAC that restricts the production rate will not be a problem.

SEATING NIPPLE

COLLAR

BUSHING 8RD X 11-1/2V

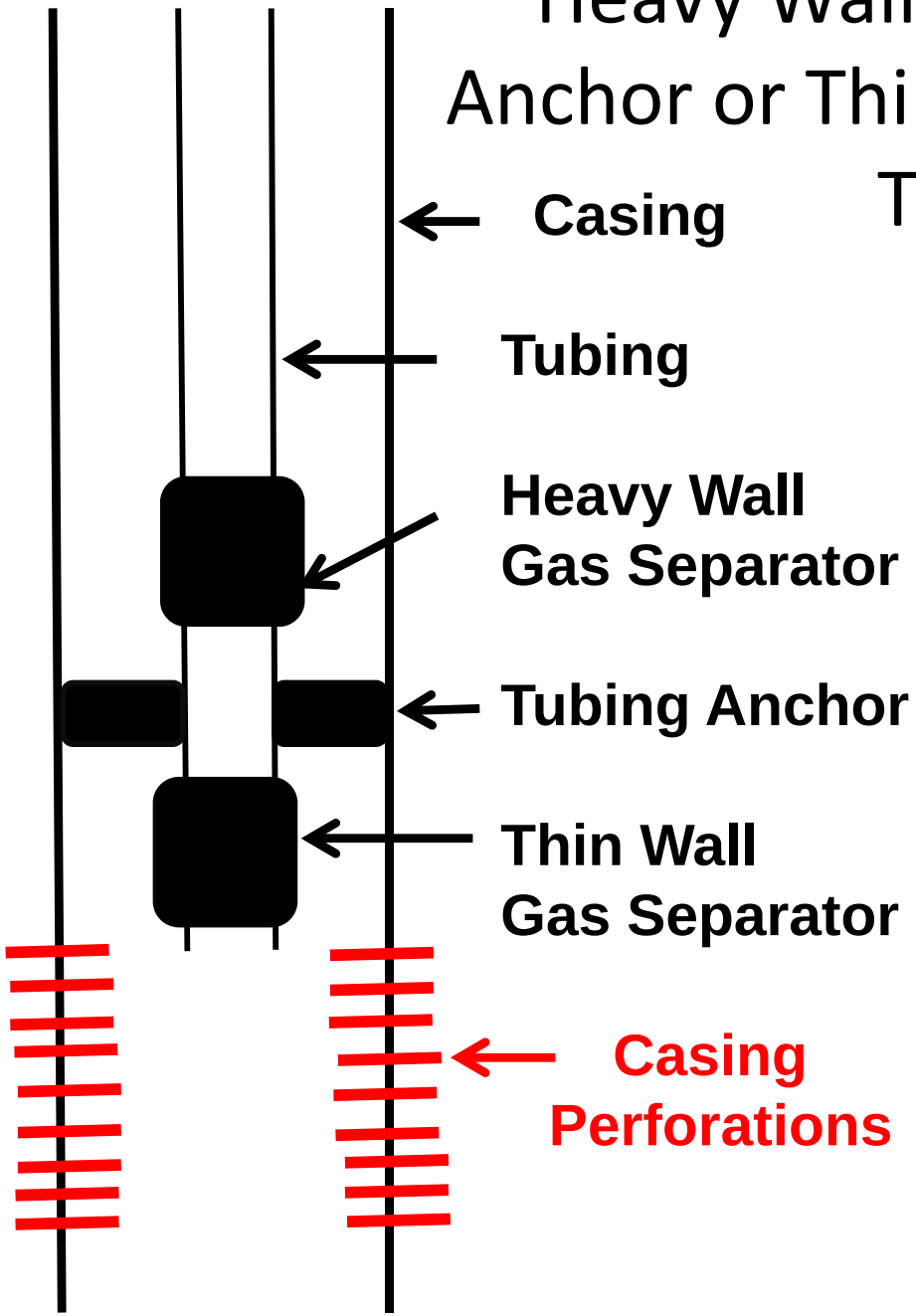
Two 1 ¼ inch holes at the top of the heavy wall outer barrel allow gas to flow out of the separator.

Two 1 ¼ inch wide liquid inlet slots are located 5 inches below the upper vent holes.

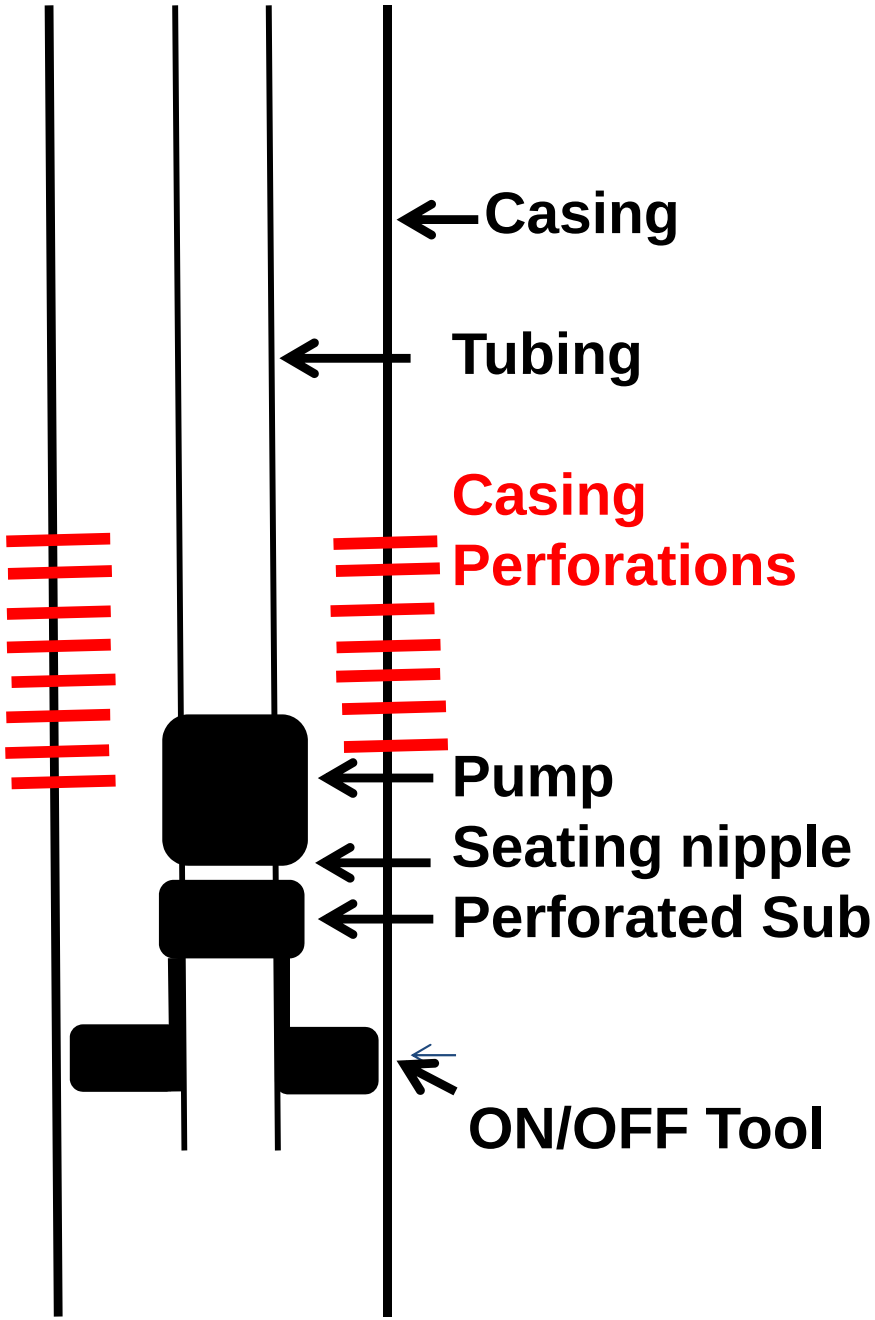
The outer barrel is heavy wall to allow a TAC to be placed below the separator and pump and seating nipple.

A TAC or mud anchor or bull plug attaches to bottom of separator.

Heavy Wall Separator Above Tubing Anchor or Thin Wall Separator Below the Tubing Anchor?

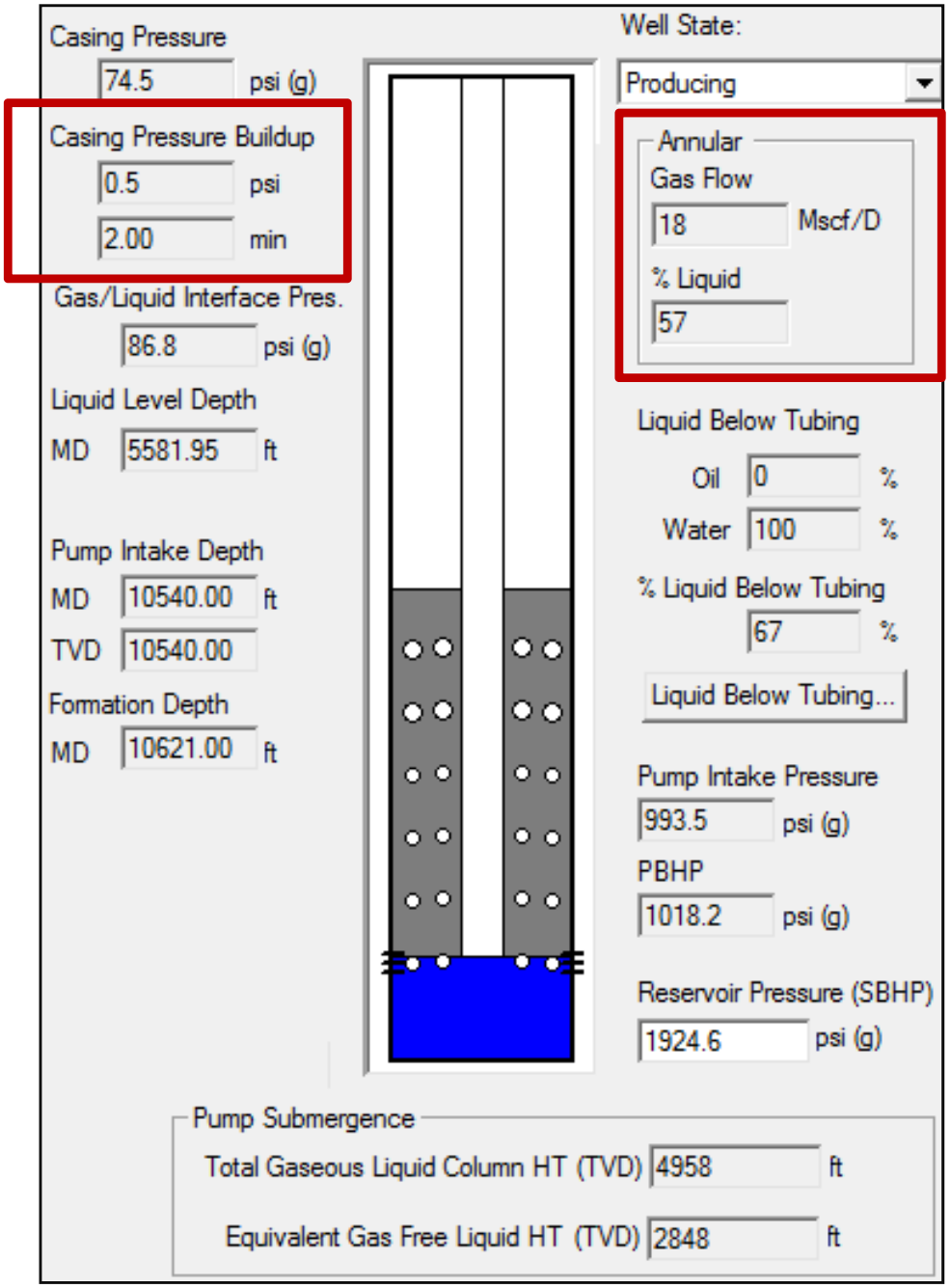


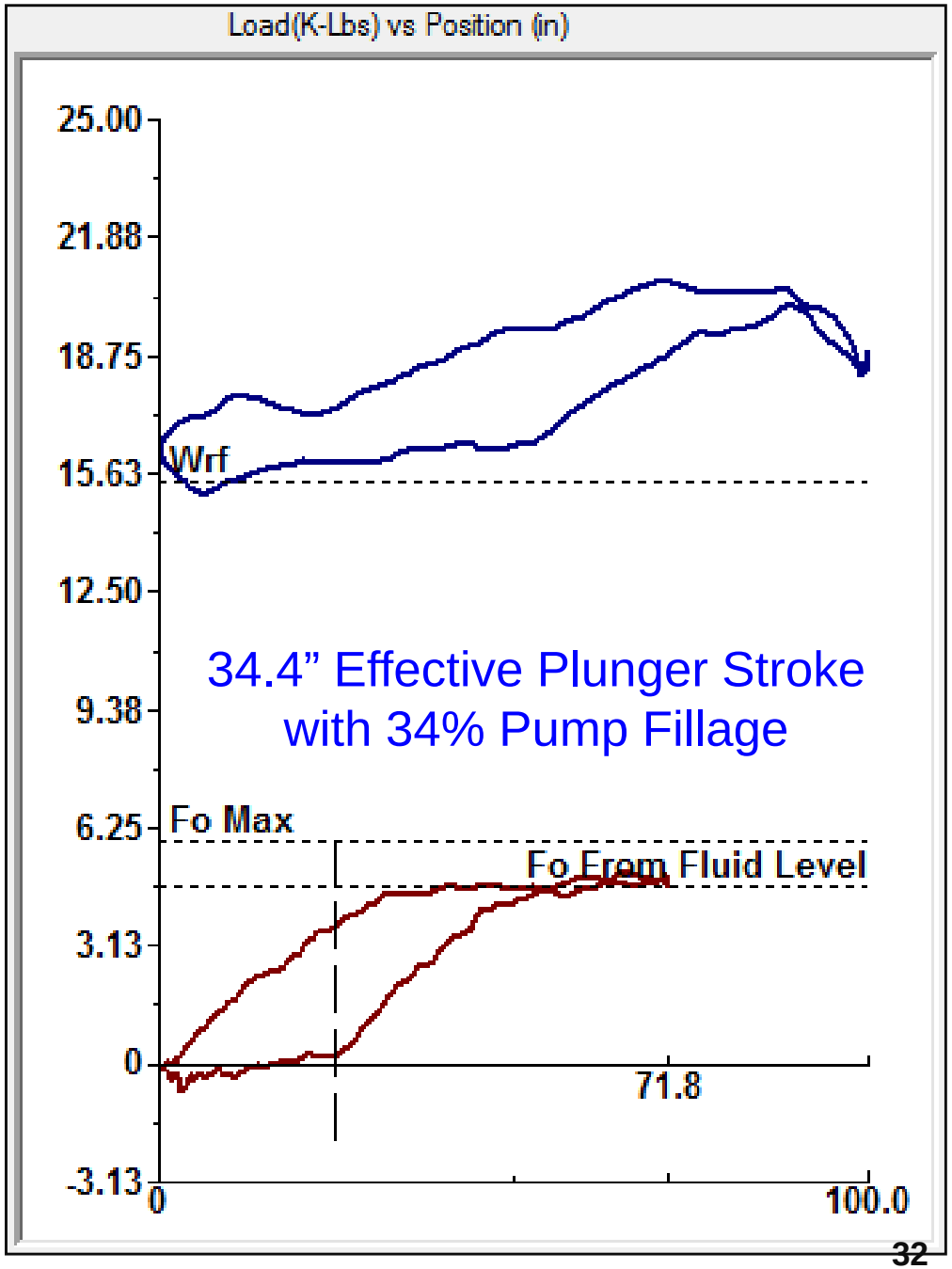
- Heavy wall collar size separator can be set above the tubing anchor
- Problem of gas accumulation below the tubing anchor is not a problem because the liquid above the TAC will be produced.
- Field tests should be performed to determine the preferred location for the gas separator.



Some operators run an ON/OFF tool below the pump and perforated sub to reduce recovery problems.

Poor Boy Separator FAILS Franks #1





Collar Sized Gas Separator OK Franks #1

Casing Pressure
36.6 psi (g)

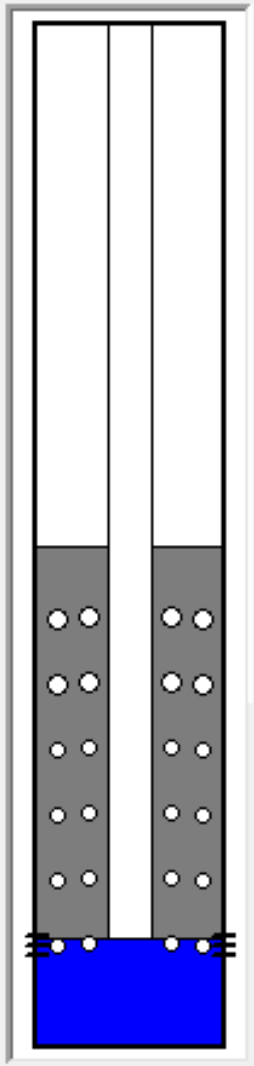
Casing Pressure Buildup
1.8 psi
1.00 min

Gas/Liquid Interface Pres.
43.7 psi (g)

Liquid Level Depth
MD 5449.90 ft

Pump Intake Depth
MD 10530.00 ft
TVD 10530.00

Formation Depth
MD 10621.00 ft



Well State:
Producing

Annular
Gas Flow
161 Mscf/D
% Liquid
22

Liquid Below Tubing
Oil 0 %
Water 100 %

% Liquid Below Tubing
40 %

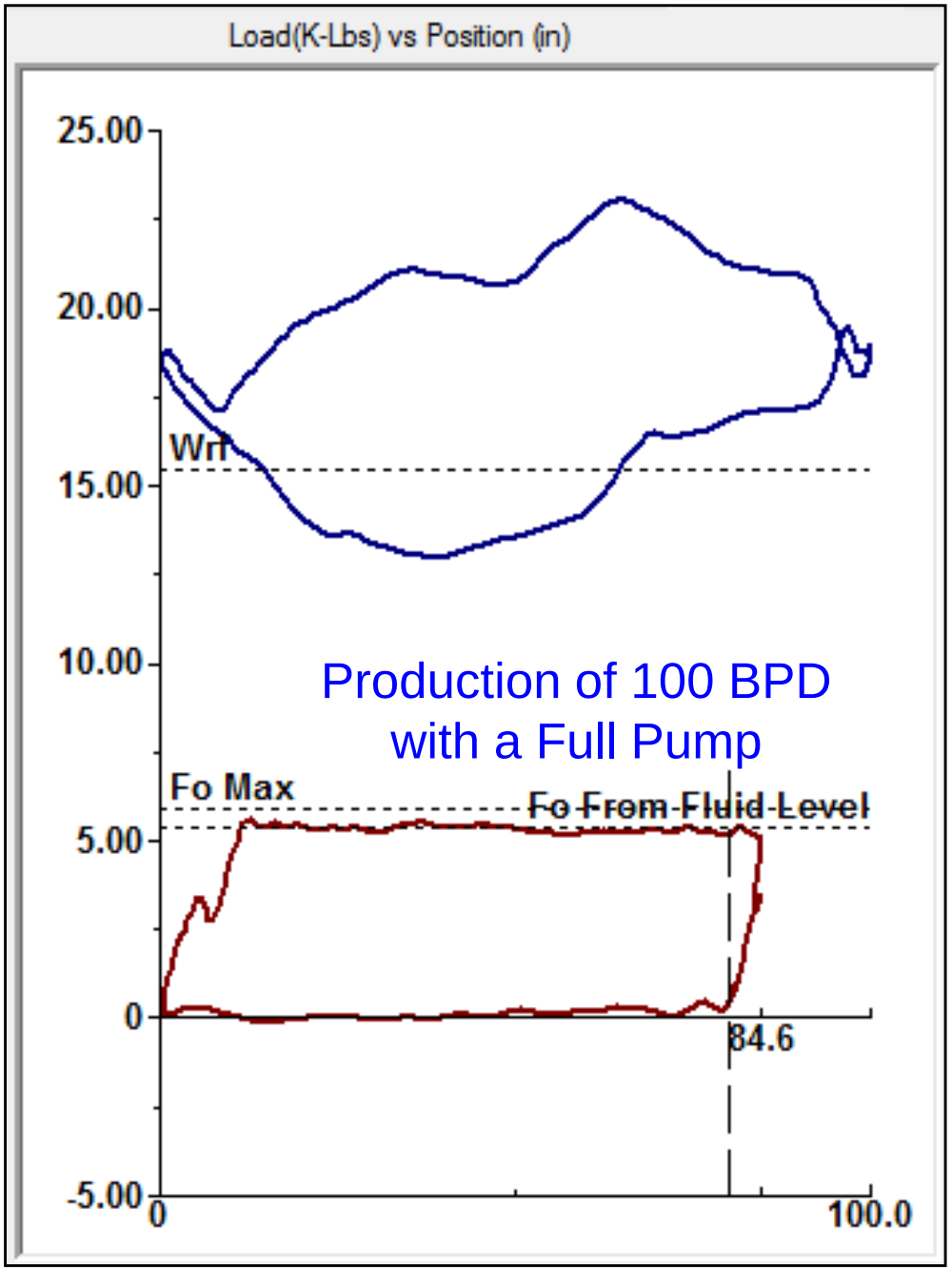
Liquid Below Tubing...

Pump Intake Pressure
415.7 psi (g)

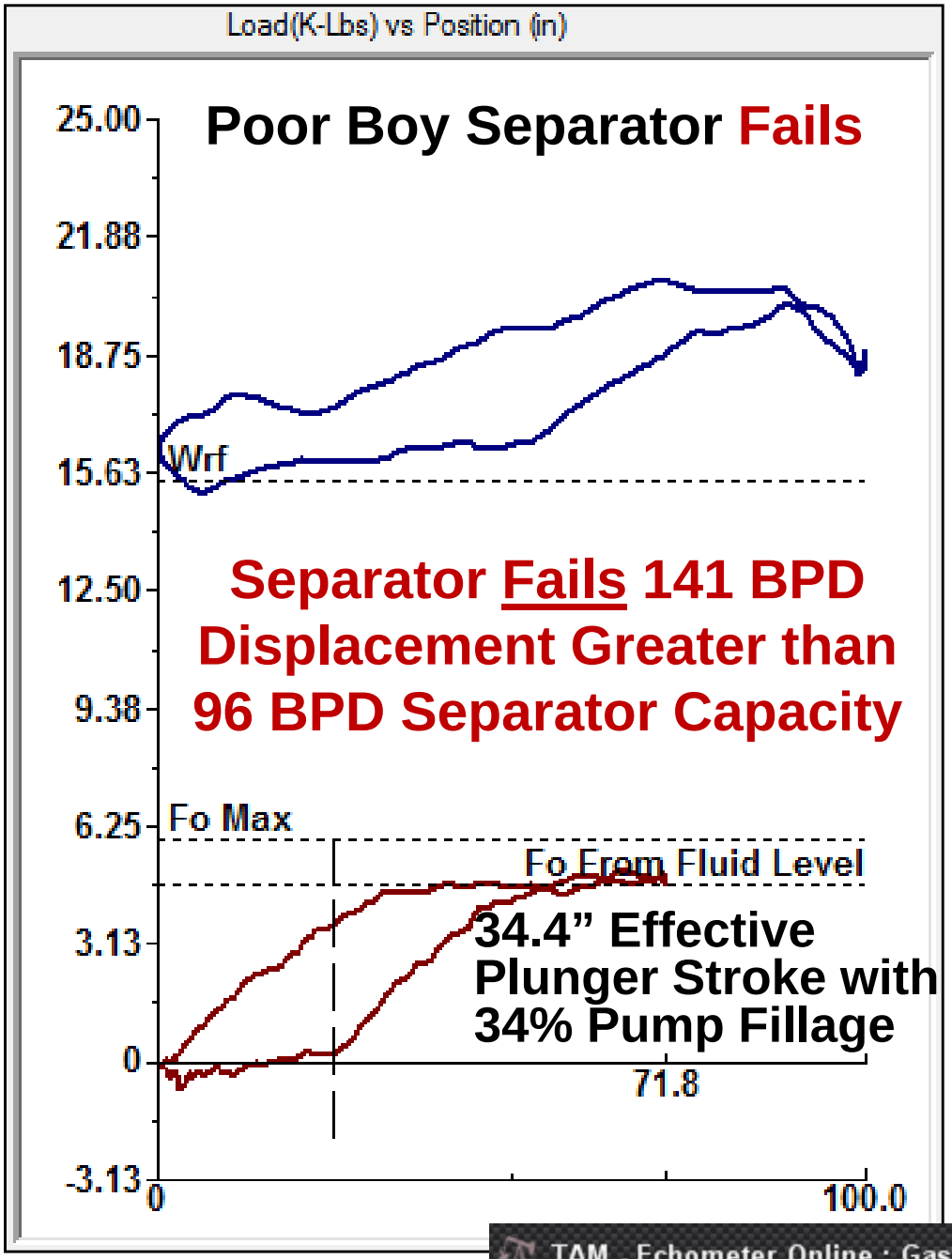
PBHP
432.4 psi (g)

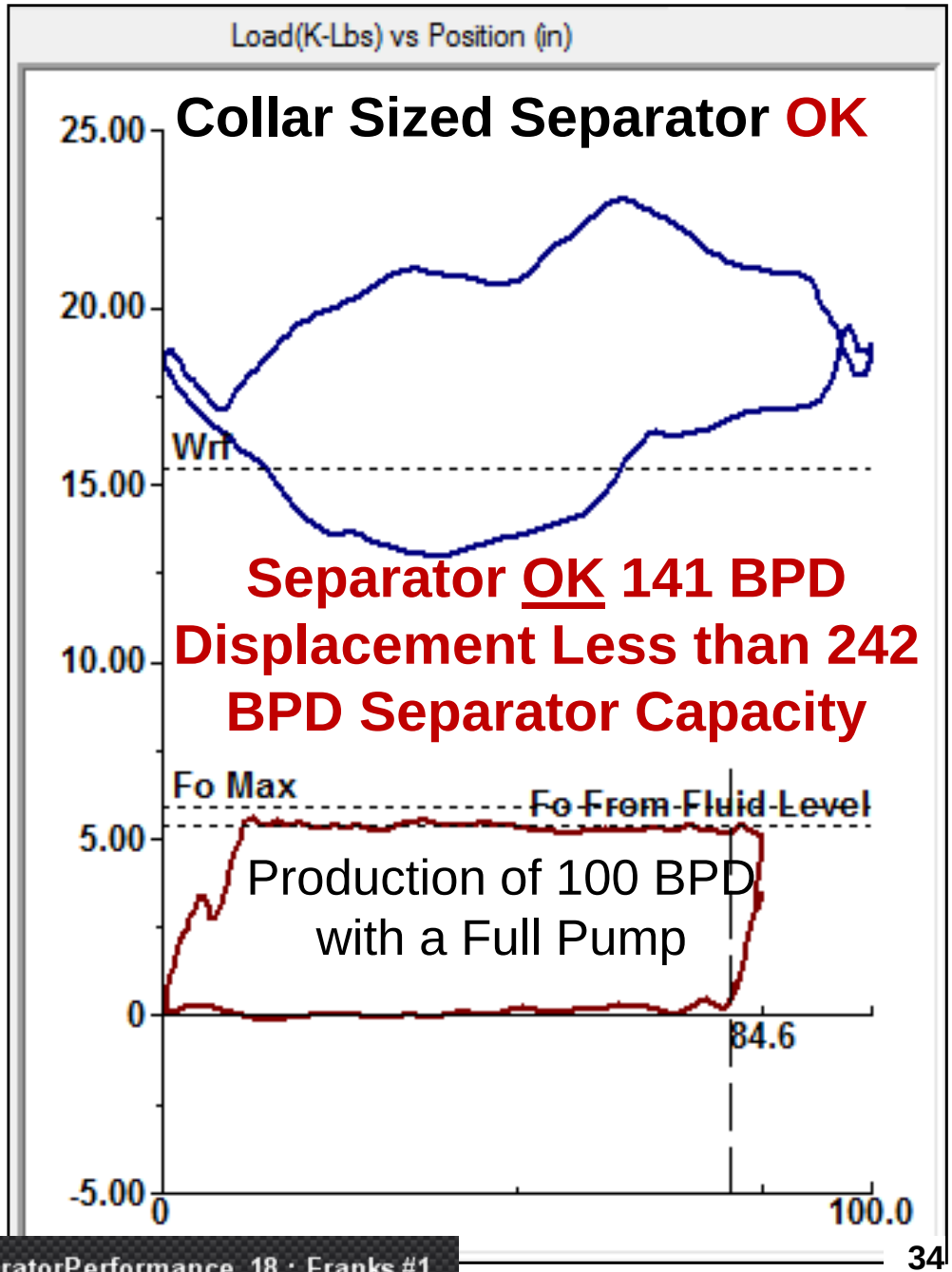
Reservoir Pressure (SBHP)
1924.6 psi (g)

Pump Submergence
Total Gaseous Liquid Column HT (TVD) 5080 ft
Equivalent Gas Free Liquid HT (TVD) 1140 ft



If Pump Capacity Exceeds Gas Separator Capacity then Gas Separator Fails

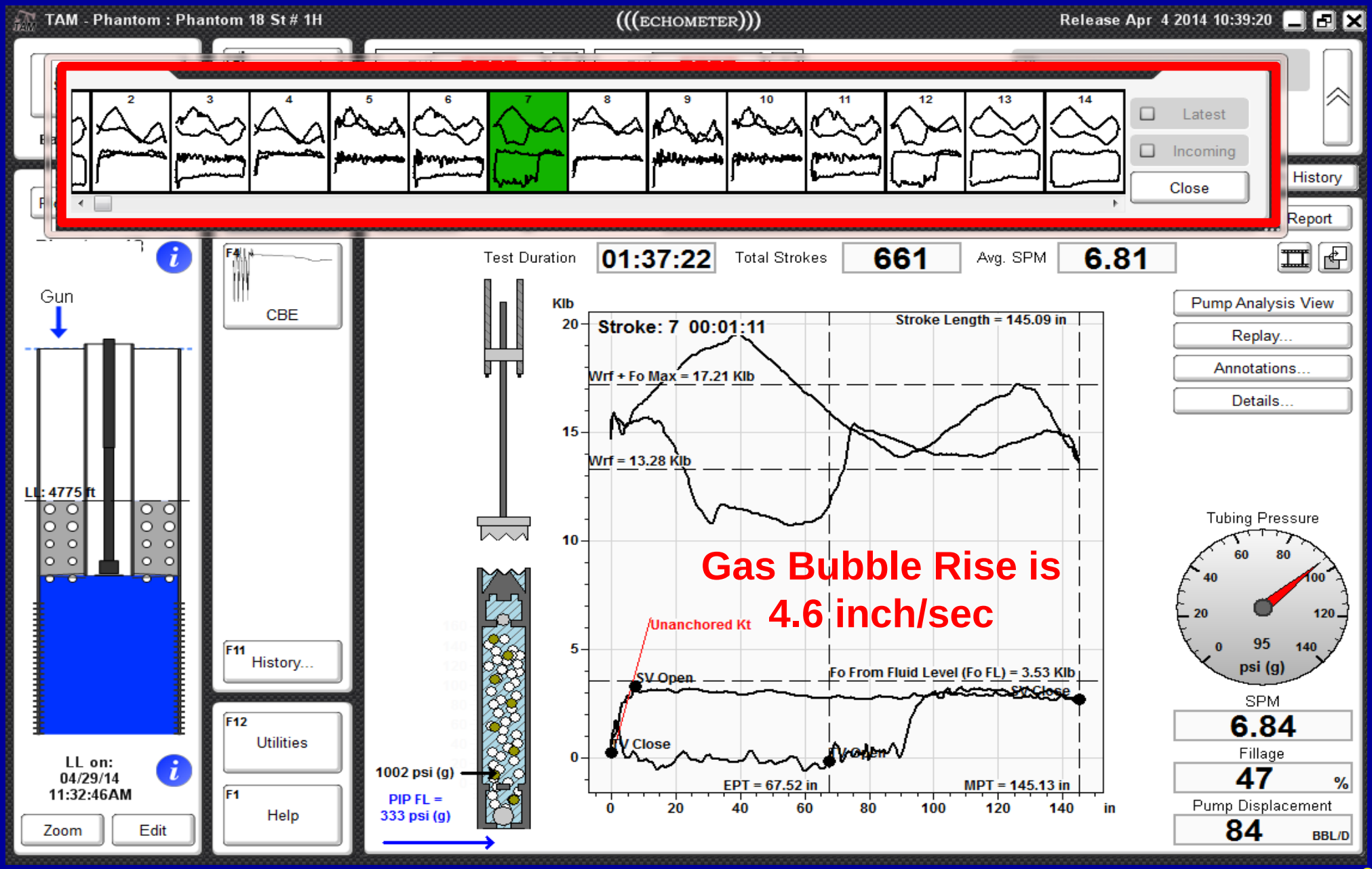




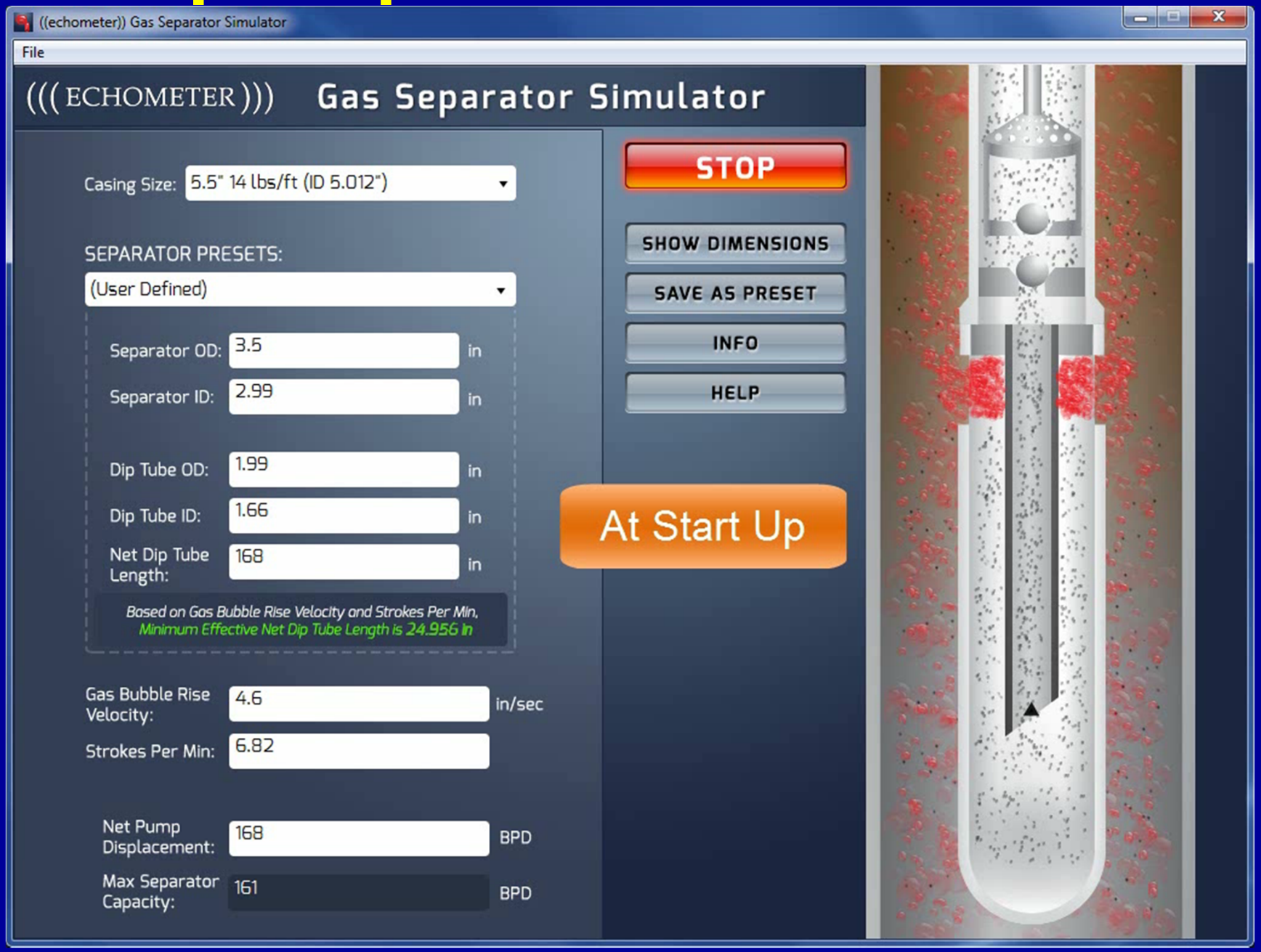
TAM - Echometer Online : GasSeparatorPerformance_18 : Franks #1

161 Capacity Poor Boy Separator Fails

Net Pump Displacement = 168 BPD @ 6.82 SPM



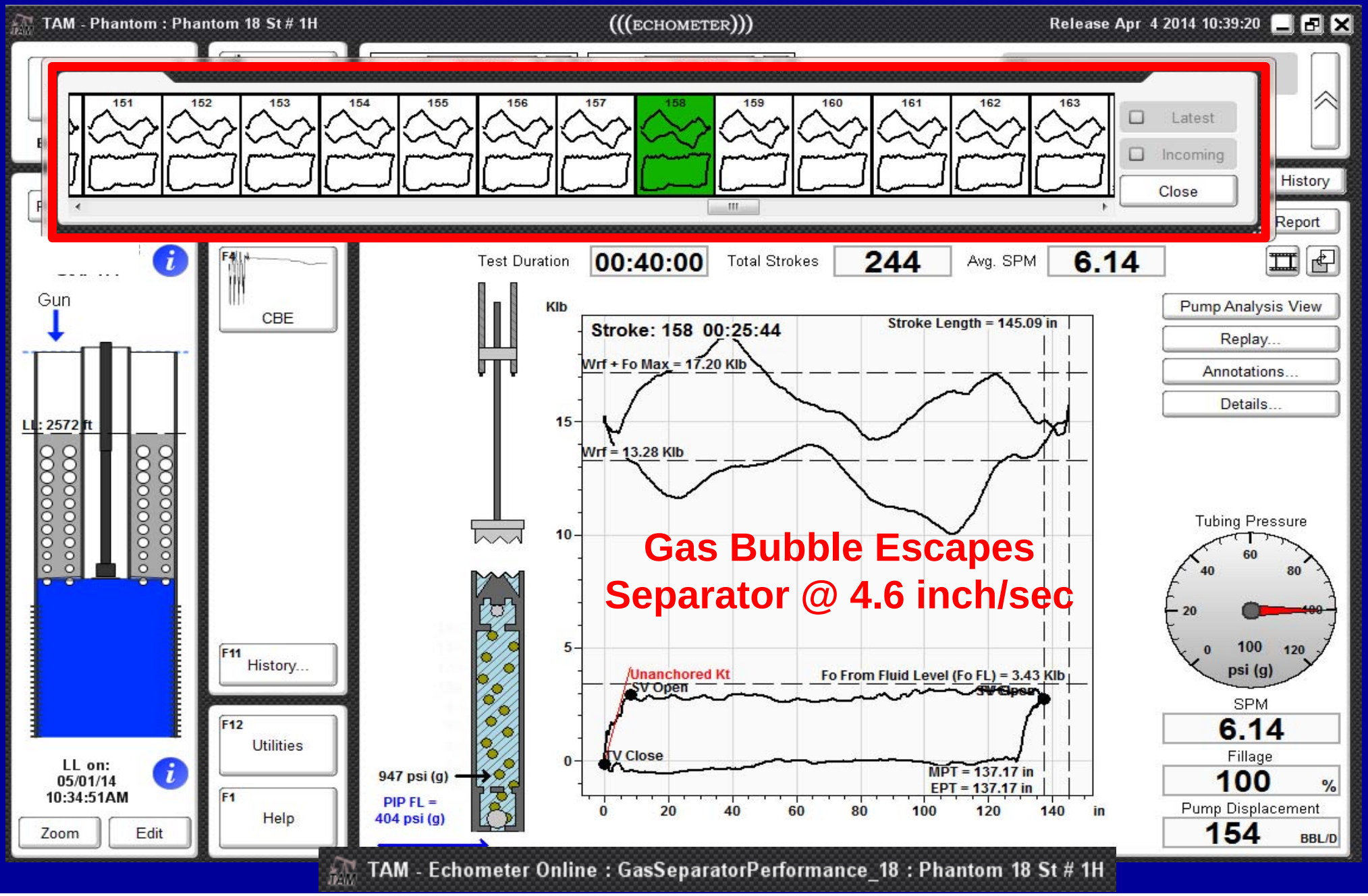
Modified Poor Boy Separator
Net Pump Displacement 168 BPD



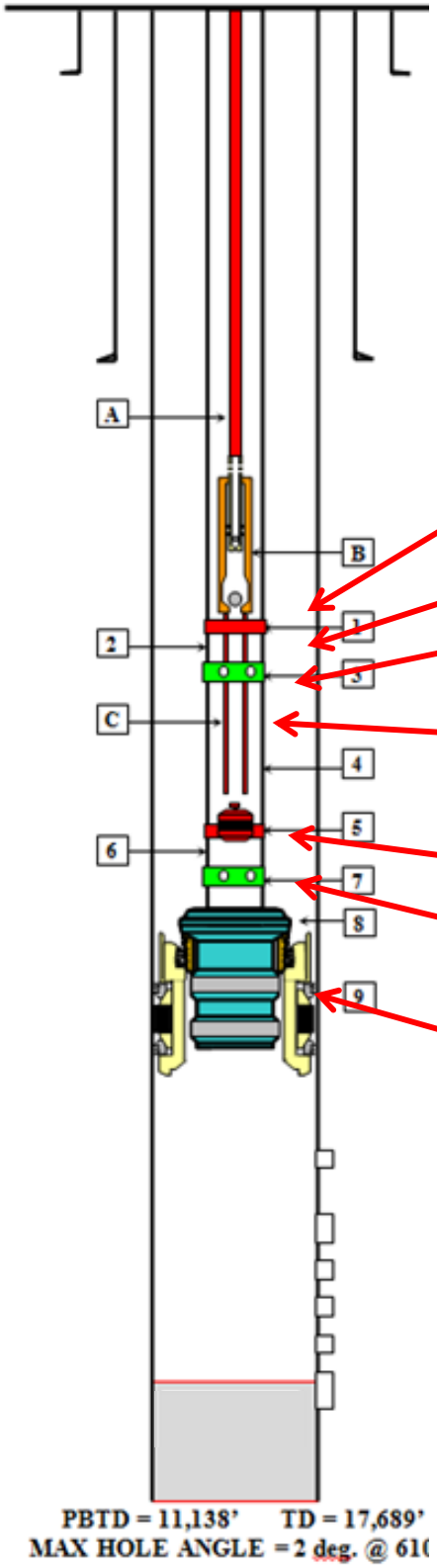
161 Capacity Poor Boy Separator

OK

Net Pump Displacement = 140 BPD @ 6.14 SPM



Longer is NOT better



Seating Nipple

6 foot 2 7/8 sub

6 foot 2 7/8 Perforated Sub

60 Foot 1 ¼ inch dip tube

Tubing Plug

6 foot Perforated sub

Baker Latch Assembly

Low Capacity Gas Separator

2 7/8 inch Poor-Boy Separator with 60 foot dip tube

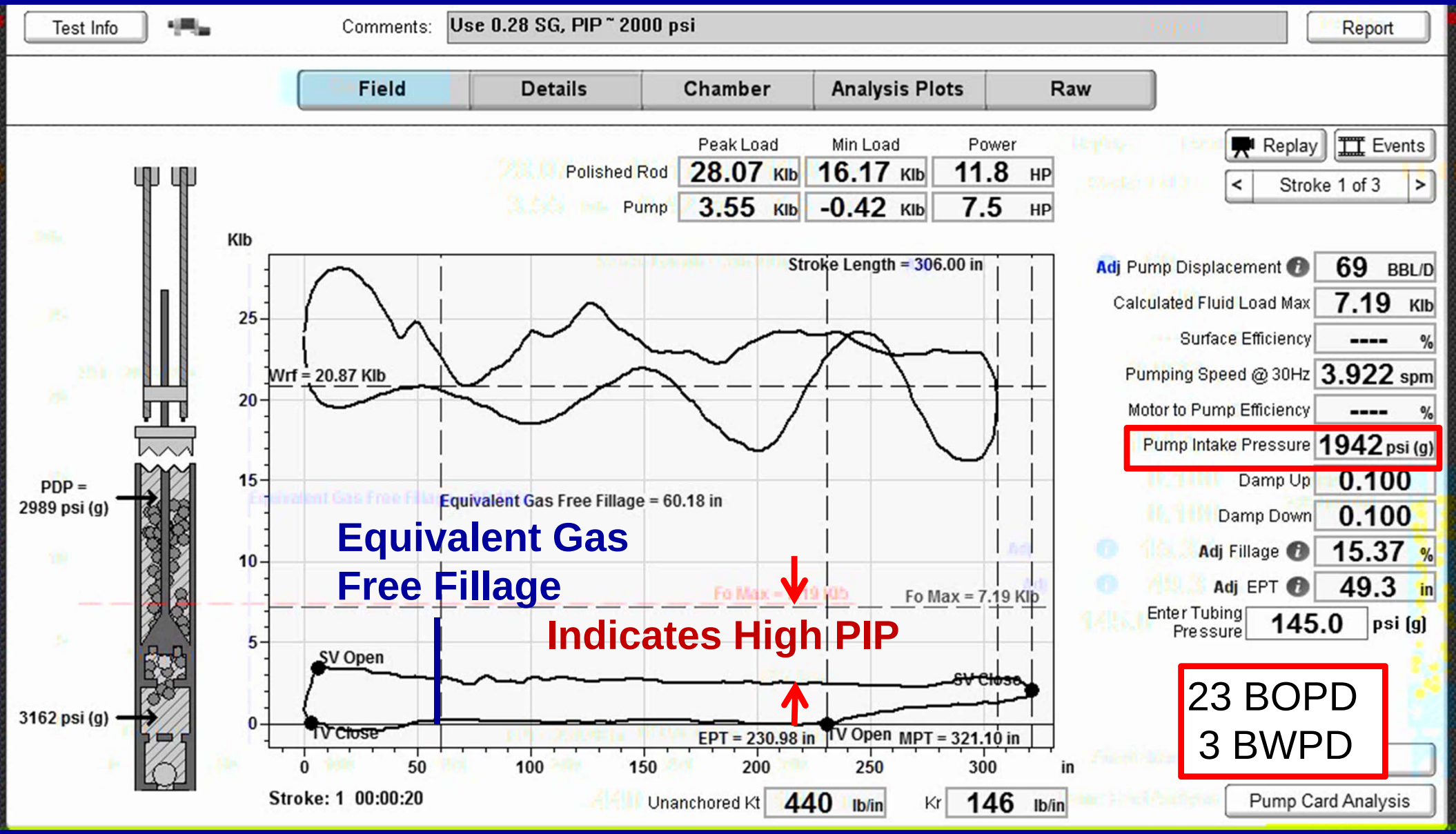
<u>324 BPD</u> Pump Displacement

EXCEEDS

<u>147 BPD</u> Separator capacity

RotaFlex Unit At High Pump Intake

Pressure the Pump Fills with 80% Free Gas



((echometer)) Gas Separator Simulator

File

(((ECHOMETER))) Gas Separator Simulator

Casing Size: 5 1/2" (5.5)

SEPARATOR PRESETS:

(User Defined)

Separator OD:	2.875	in
Separator ID:	2.5	in
Dip Tube OD:	1.66	in
Dip Tube ID:	1.38	in
Dip Tube Length:	720	in

ERROR:
Dip Tube Length must be between 12" and 240"
Recommended Range: 40"-60"

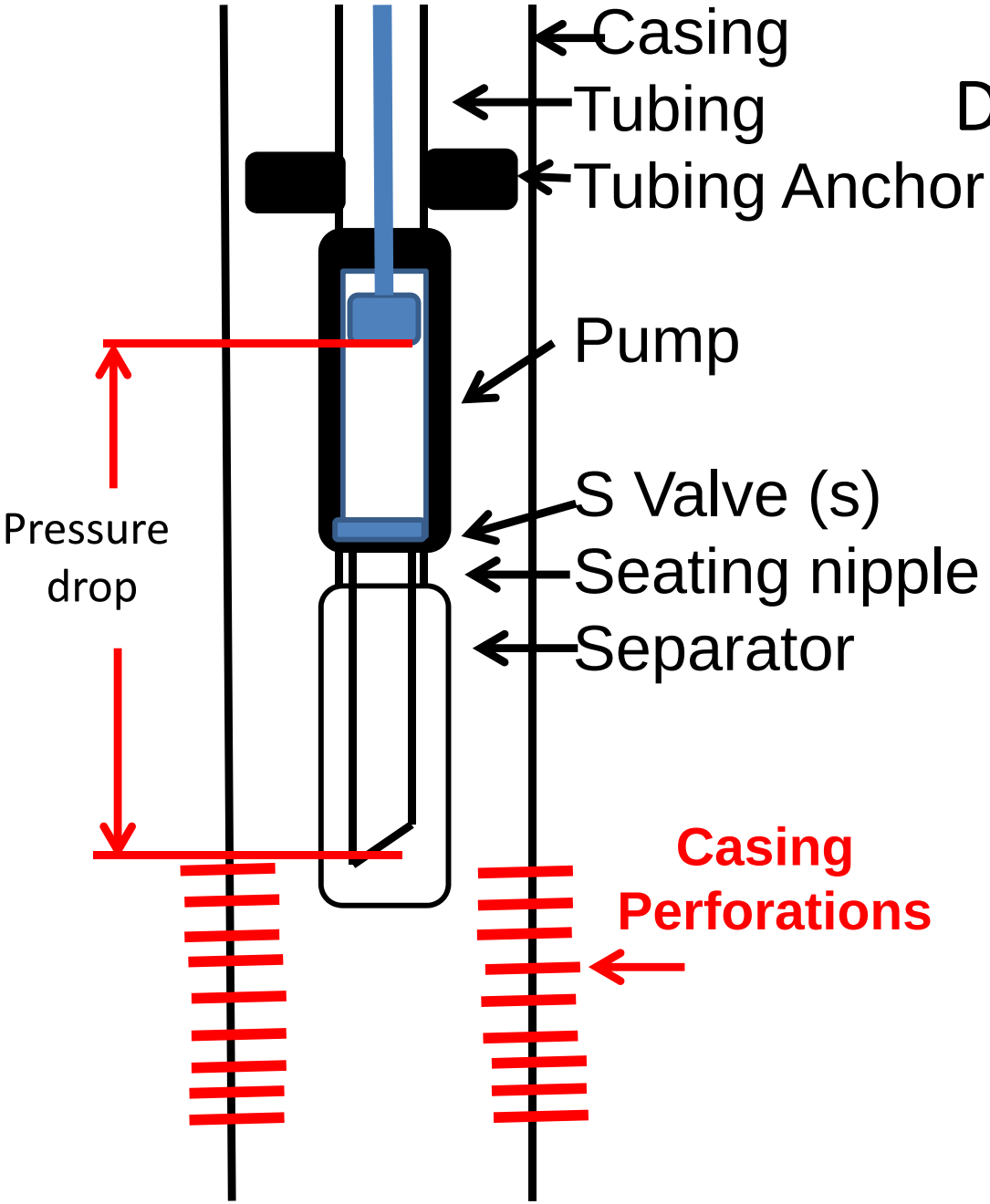
Gas Bubble Rise Velocity:	6	in/sec
Strokes Per Min:	4	
Net Pump Displacement:	324	BPD
Max Capacity:	147	BPD

STOP

SHOW DIMENSIONS

HELP

OVER CAPACITY

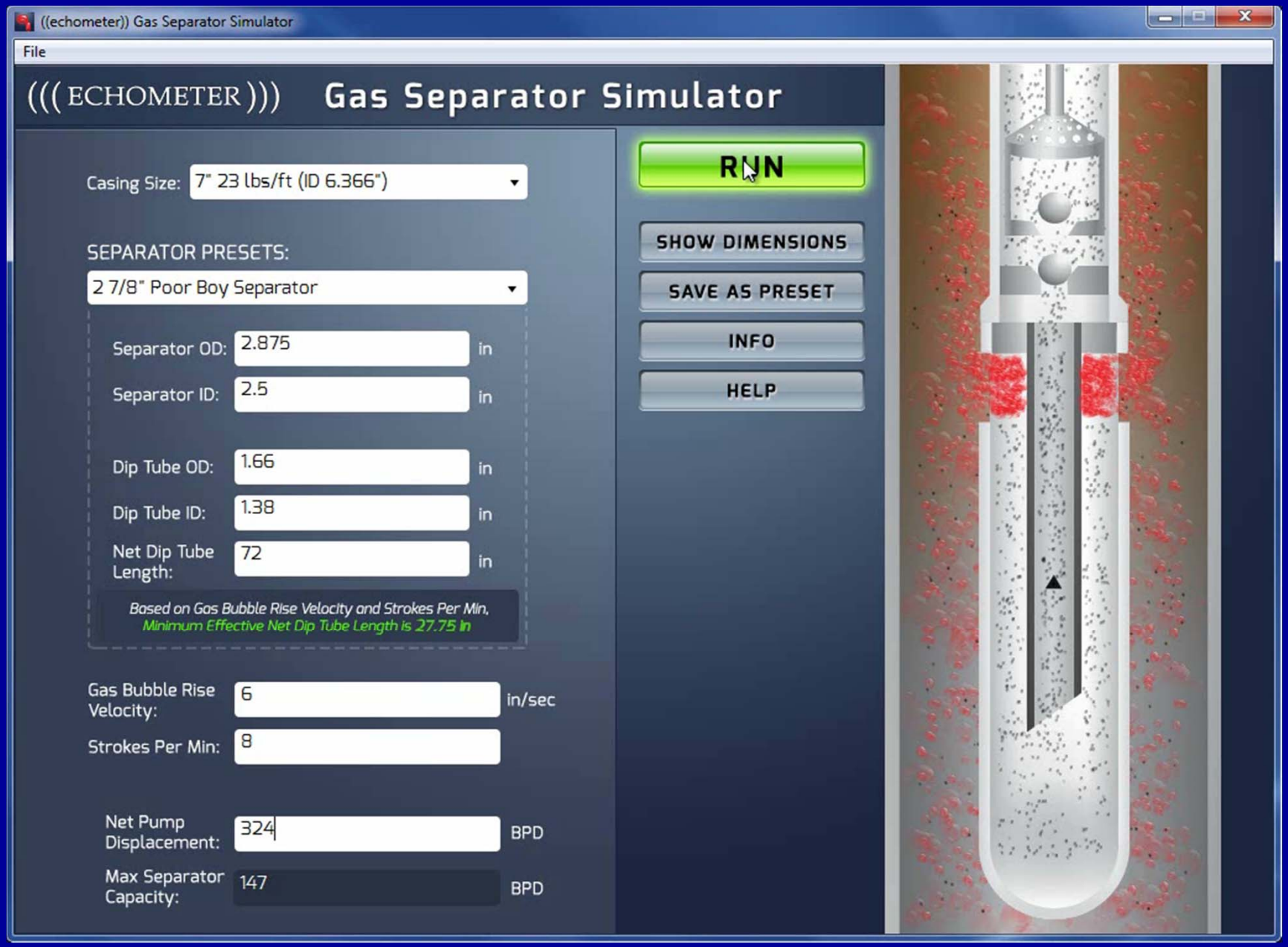


Long Dip Tubes Decrease Separator Efficiency

A pressure drop occurs when the liquid travels from the bottom of the dip tube up through the dip tub, through the standing valve (s) and up through the plunger barrel as the plunger moves upward due to friction, hydraulic head loss and inertia.

A 40 psi pressure drop causes gas to be liberated from the oil that has the same volume at STP as the oil volume.

$125K 147 BPD Poor Boy Separator Fails
60 Ft Long Dip tube Does NOT Help



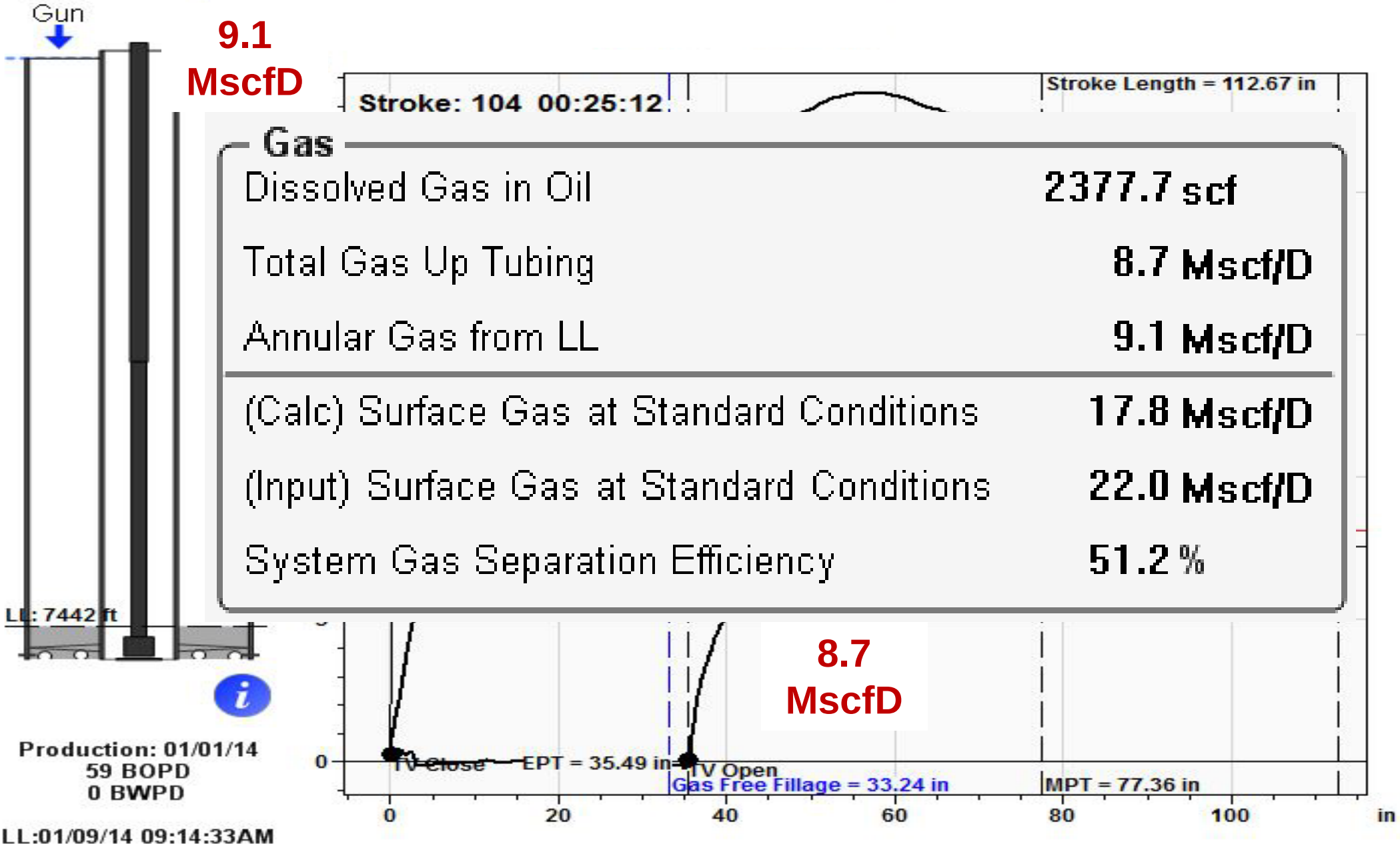
Analysis of Gas Separation Performance

- **Inefficient gas separators can be identified by:**
  1. **Obtaining an acoustic liquid level test indicating a high gaseous liquid column above the pump**
  2. **Analysis of dynamometer data indicating a large portion of the fluids entering the pump is gas resulting in incomplete pump fillage.**
- **Periodic acoustic liquid level tests and dynamometer measurements should be performed to verify:**
  1. **Pump is filled with liquid**
  2. **Downhole gas separator is operating properly**

Gas Separation Efficiency Determined by Gas Produced Up the Tubing and Casing

- Gas Produced Up the Tubing Is Determined From the Pump Card Calculations
- Free Gas Produced Up the Tubing/Casing Annulus Is Determined Form the Acoustic Fluid Level Test Performed While Acquiring the Dynamometer Test Data
- Total Gas Produced Can Be Determined
- System Gas Separation Efficiency Can Be Determined By Comparing the Gas Produced Up the Casing to the Total Gas Produced.

Well's System Gas Separation Efficiency is 51.2%
Equal to 9.1/17.8 MscfD



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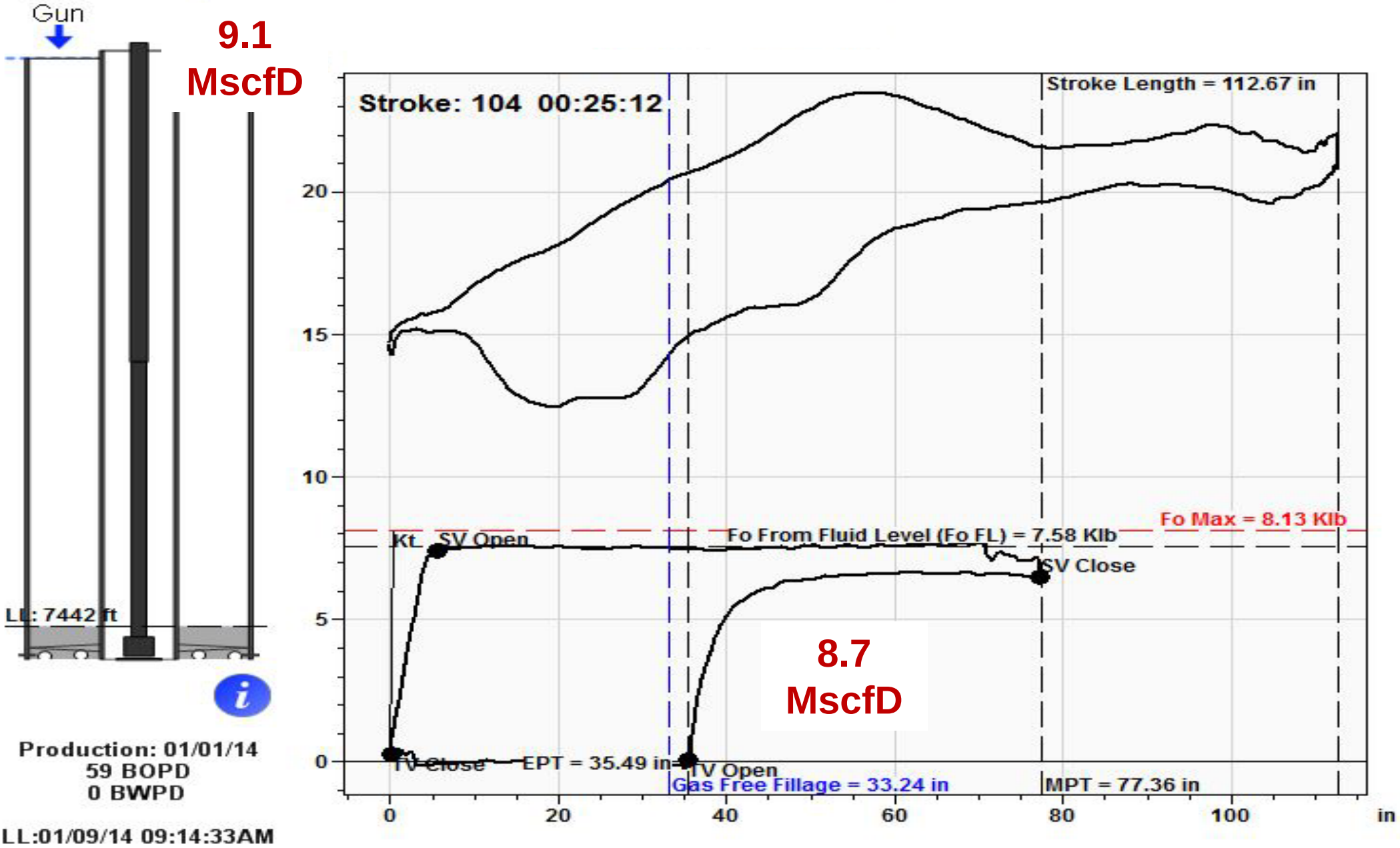


Gas Separation Capacity Based on Casing Size

Type	*Size inches*	*Separation Liquid Capacity, BPD*
Gas Separators for 4-1/2 inch Casing		
Natural Gas Separator	2 3/8	420
Collar Size Gas Separator	2 3/8	275
Poor Boy Separator	2 3/8	96
Gas Separators for 5-1/2 inch Casing		
Natural Gas Separator	2 7/8	580
Collar Size Gas Separator	2 7/8	443
Heavy Wall Gas Separator	2 7/8	372
Packer Type Separator	2 7/8	444
Poor Boy Separator	2 7/8	190
Gas Separators for 7 inch Casing		
Natural Gas Separator	2 7/8	1200
Collar Size Gas Separator	4 1/2	1044
Collar Size Gas Separator	4	833
Collar Size Gas Separator	3 1/2	644
Collar Size Gas Separator	2 7/8	443
Heavy Wall Gas Separator	2 7/8	372
Packer Type Separator	2 7/8	1089
Poor Boy Separator	2 7/8	190

Casing Size Limits Gas Separator Capacity Limits Maximum Liquid Production Rate

Casing Size Inch	Max Separator Size Inch	Tubing Collar OD Inch	Separator Barrel OD Inch	Separator Capacity BPD
4.5	2 3/8	3.063	3.063	275
5.5	2 7/8	3.668	3.668	445
7.0	3 1/2	4.500	4.500	644
7.0	4	5.000	5.000	833
7.0	4 1/2	5.560	5.500	1044

4.5 13.5# Casing ID 3.92 inch
5.5 17# Casing ID 4.89 inch
7.0 26# Casing ID 6.276 inch

SWPSC_2017_DownHoleGasSeparationandPerformance.pdf

Gas Separator Recommendations

1. Use a Natural Gas Separator unless well conditions are unfavorable.
2. When the separator is above the producing zone, the outer barrel of the gas separator should be about 80% of the casing internal diameter in high producing rate wells.
3. Gas separator capacity should exceed the pump capacity.
4. Use the Echometer Gas Separator Simulator Software Program to determine gas separator capacity.
5. Use dynamometer and fluid level analysis to determine pump fillage and separator efficiency.
6. Determining gas separator efficiency from pump fillage when using high slippage pumps can be very misleading since the separator may be separating very little liquid from gas and the actual liquid production rate may be very low.
7. The bottom of the dip tube should extend below the bottom of the gas separator inlet ports approximately 200/SPM inches.

Observations

- Installing very long separators does not increase separator capacity or efficiency.
- Restrictions in the annulus above the pump intake such as tubing anchors result in reduced annular gas flow with gas preferentially entering the pump.
- A downhole gas separator has a maximum liquid capacity.
- Casing size restricts the maximum size gas separator that can be installed in a well.
- Separator used in a well should be designed for the well configuration/conditions.
- Gas Separators with high separation efficiency should be used to effectively produce sucker rod lifted wells.

Conclusion

- Expected performance of downhole gas separators can be calculated based on net pump displacement rates, size of separator, planned SPM and a gas bubble rise velocity.
- Downhole Gas Separator Simulation program predicts how a separator will perform in the field so that the proper gas separator and pump can be selected.
- Operators can analyze a particular separator configuration and view how the gas separator separates the liquid from the gas and also determine separator capacity.
- To effectively produce sucker rod lifted wells Gas Separators should be used within their operational limits

What About Gas Separation In Horizontal Wells?

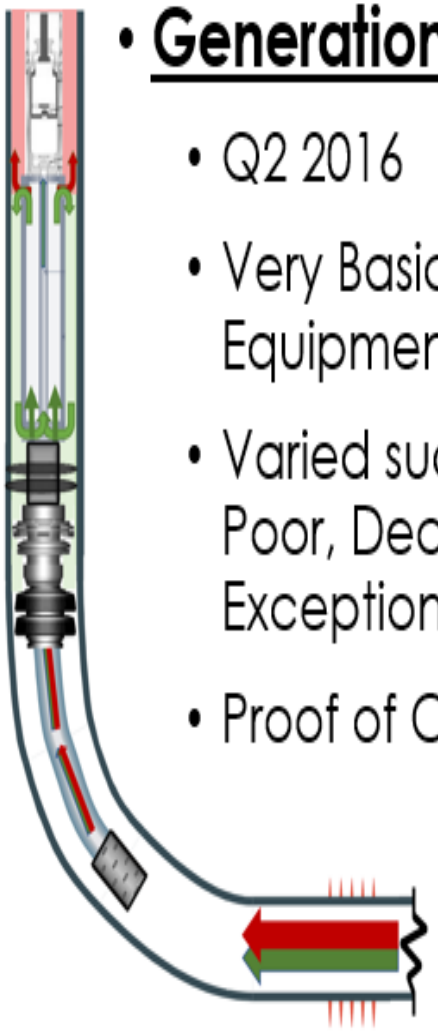
Ultimate Production System: Evolving and Delivering Results

(((ECHOMETER)))

Intended Deliverables from UPS Offerings

- Operate from the most conducive wellbore positions
- Maximize uptime/minimize failures/improve LOE
- Increase production and sustain the incremental lift
- Fully deliquefy the lateral and trough of curve, yielding production uplift otherwise unachievable

UPS Evolution to Current State

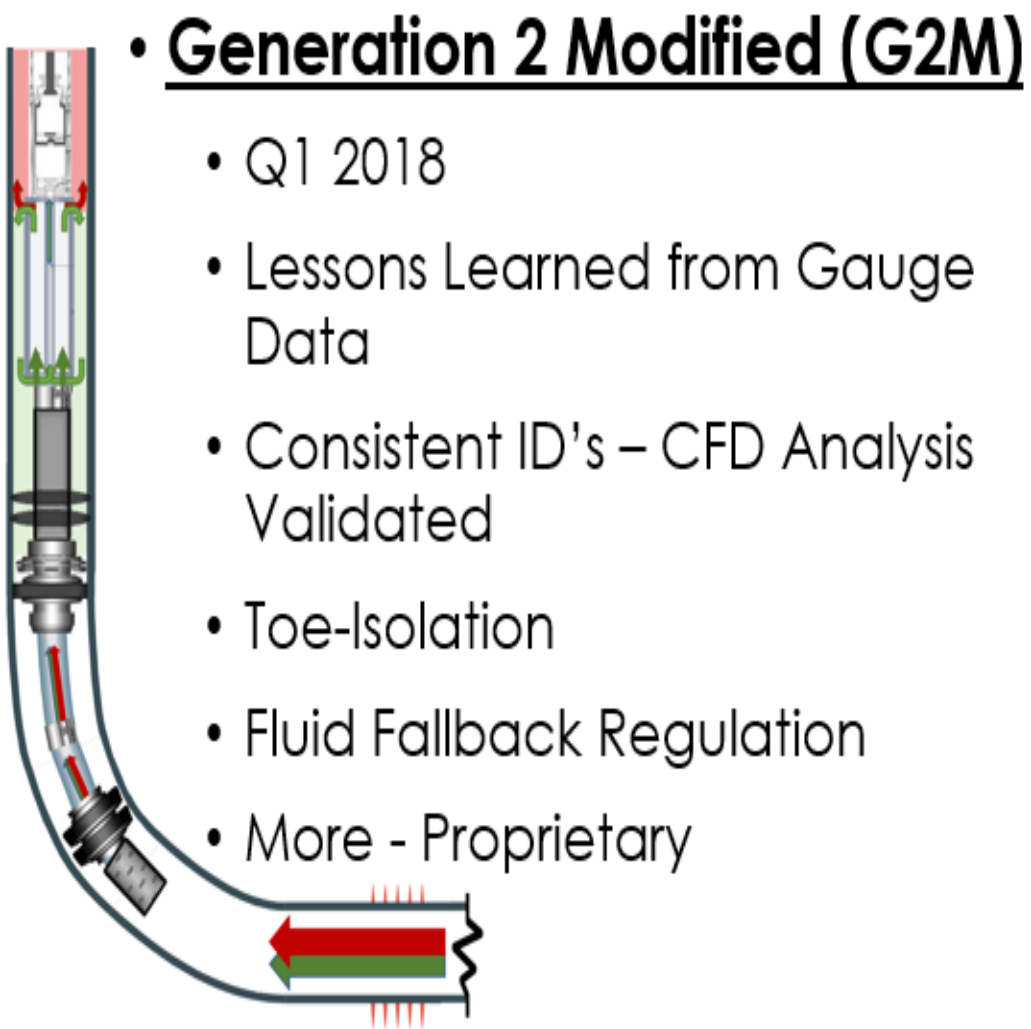


- **Generation 1 (Gen1)**
  - Q2 2016
  - Very Basic Equipment Offering
  - Varied successes – Poor, Decent, Exceptional
  - Proof of Concept

- **Generation 2 (Gen2)**
  - Q3 2017
  - Reliable Isolation
  - More Success – Led to Accelerated Learning
  - Integral Step in Validating Direction for Improvements

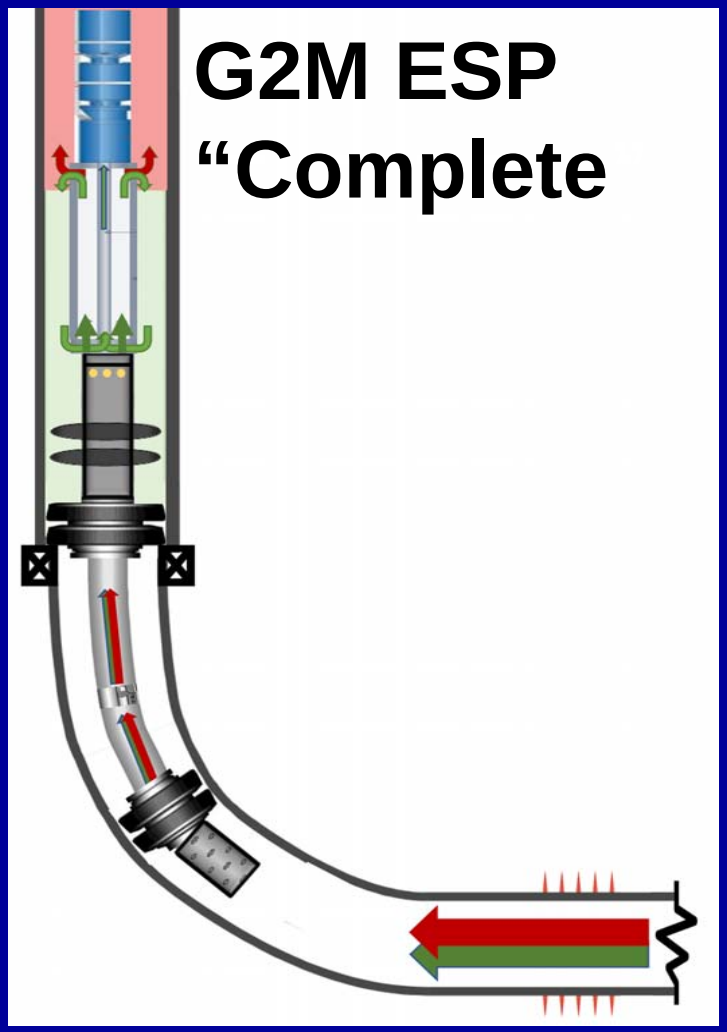
Diverter Gas Separator SWPSC 2012.pdf

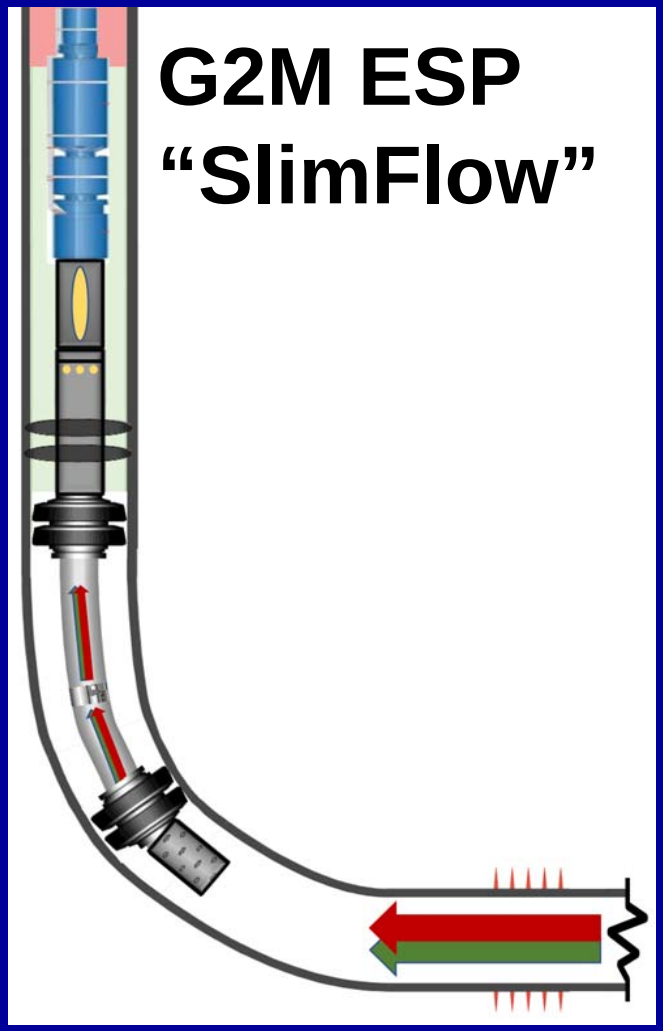
UPS Evolution to Current State

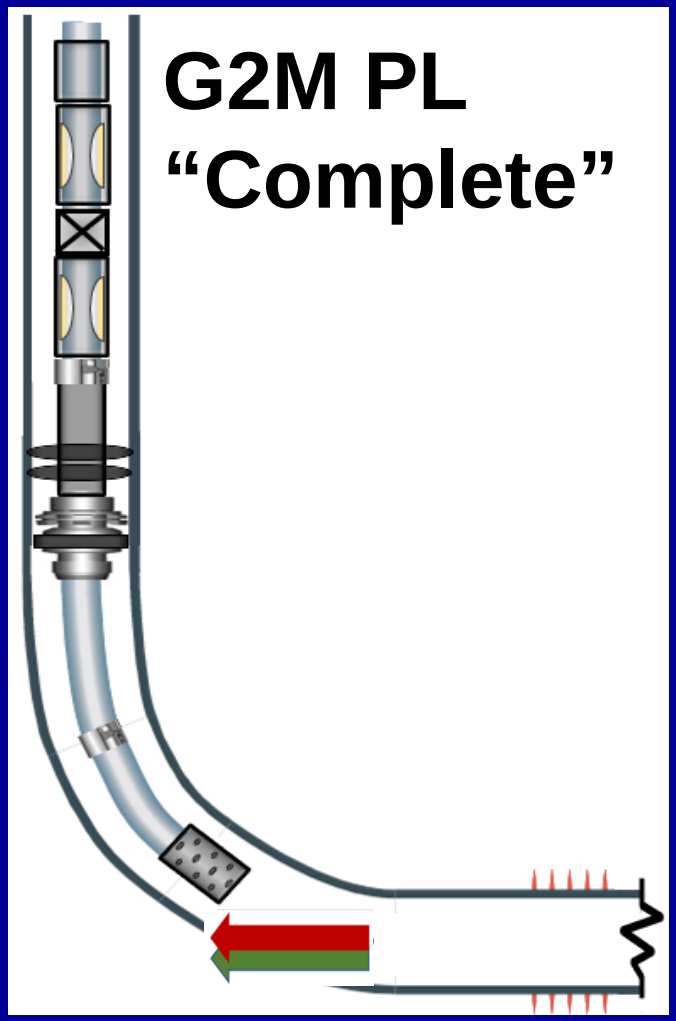


- Addition of 3 new separator options – "challenge specific"
- More customization on tailpipe sizings/materials available
- Increased safe-falls against sticking and for easy retrieval

UPS Current State:
Multiple Lift Applications







G2M UPS Take Optimization to a New Level

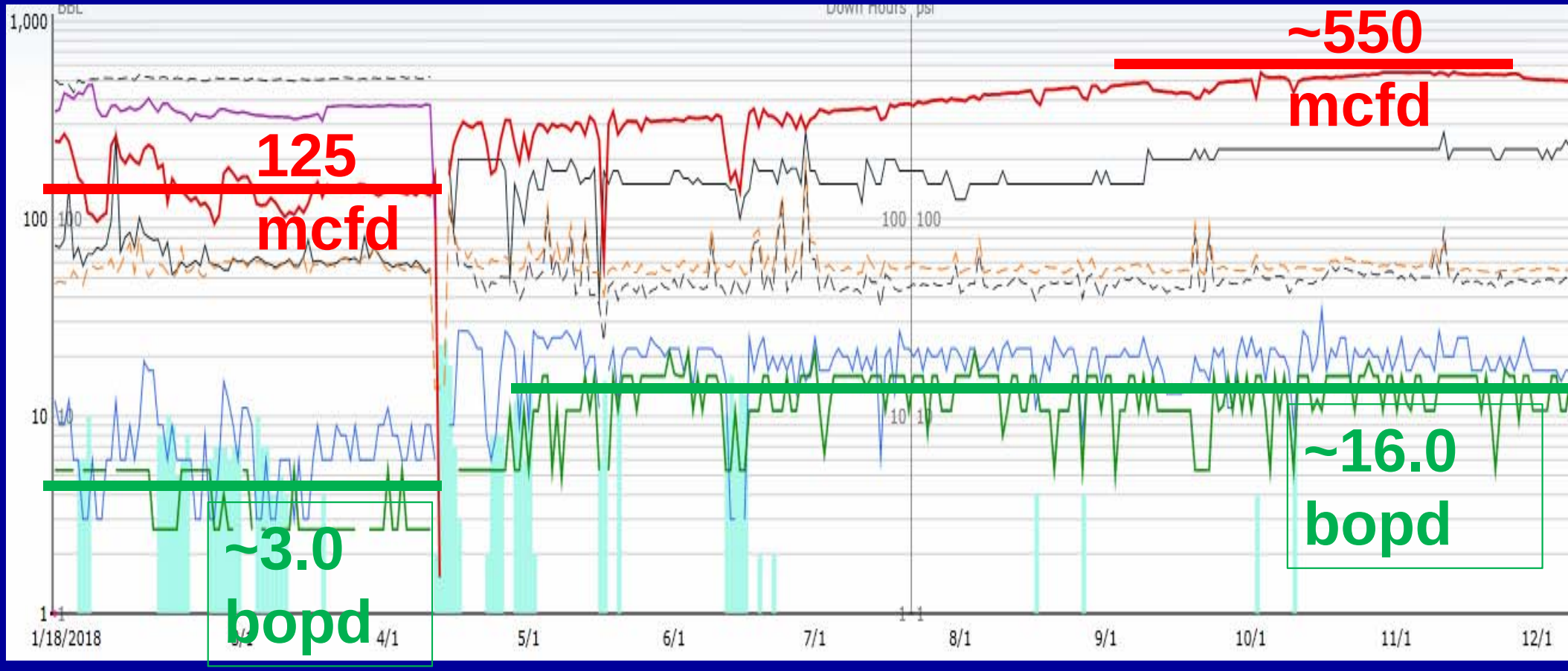
- **Solves wells' inability to lift fluids effectively due to insufficient and unsustained Superficial Gas Velocity (VSg) through the curve**

- **Yields more drawdown, but far more importantly, leads to more complete state of lateral deliquification**

- **When applied in a correct and comprehensive fashion the results far exceed reasonable expectations**

What's the Result?

UPS Well #1H: 22 MBO + 650 MMCF---------- **(Updip well online +8 months)**

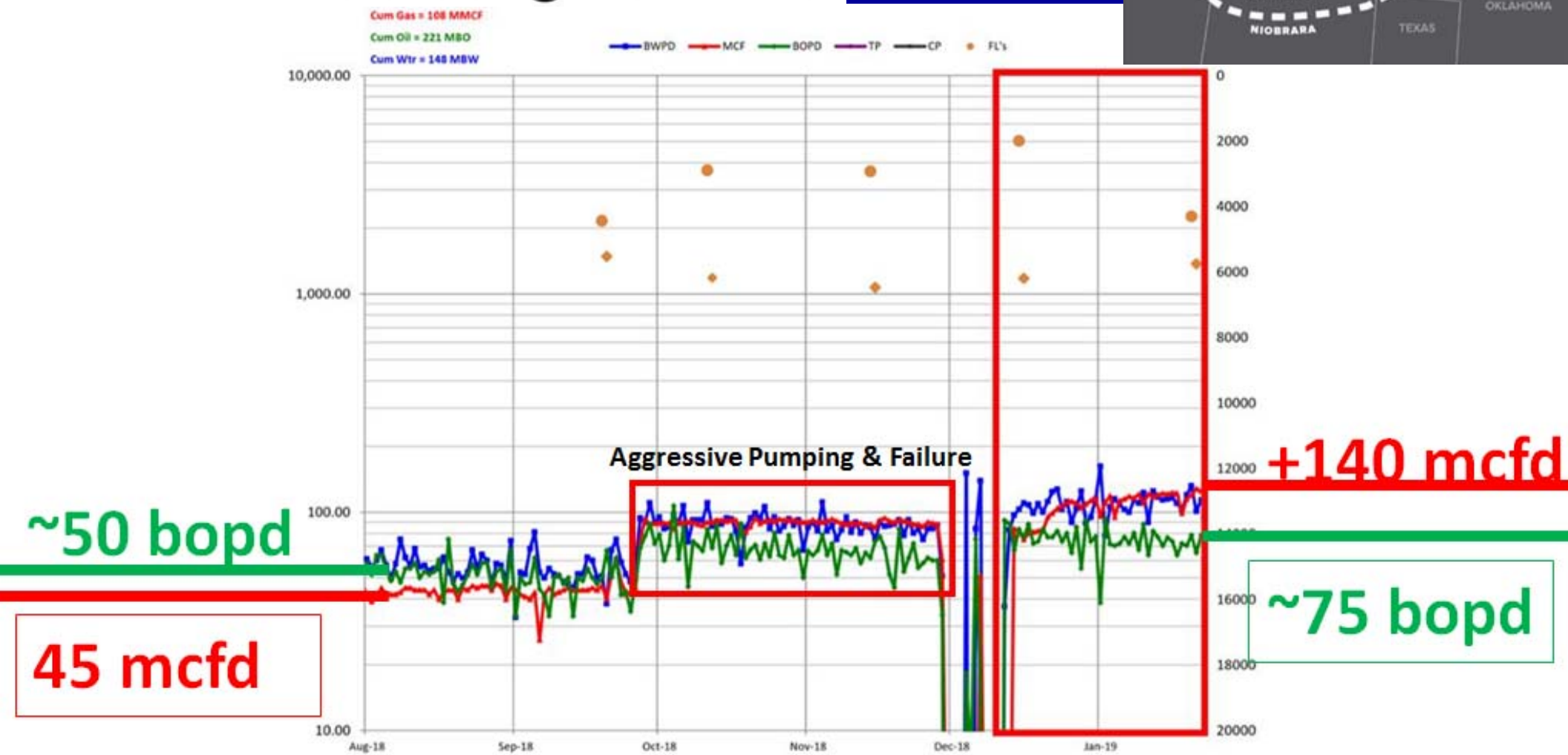


Oil = ------- Water = ------- Gas = -------

What's the Result?

Niobrara

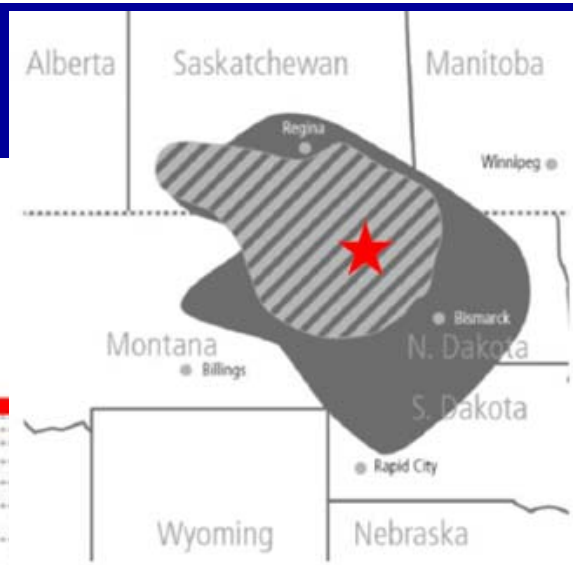
- Continuing to climb

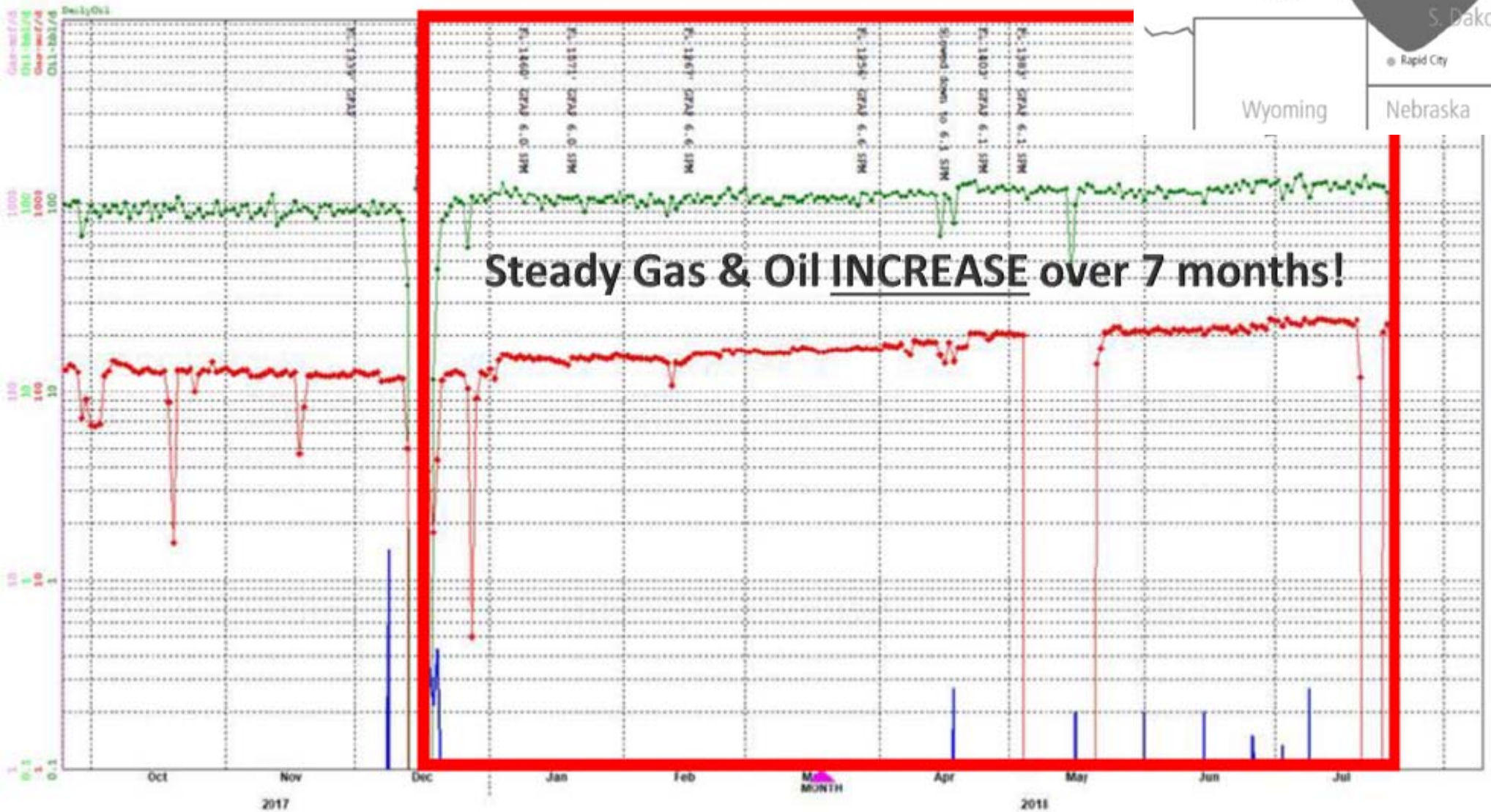


Oil = ------- Water = ------- Gas = -------

Bakken Results!

$350,000 incremental production added over seven months

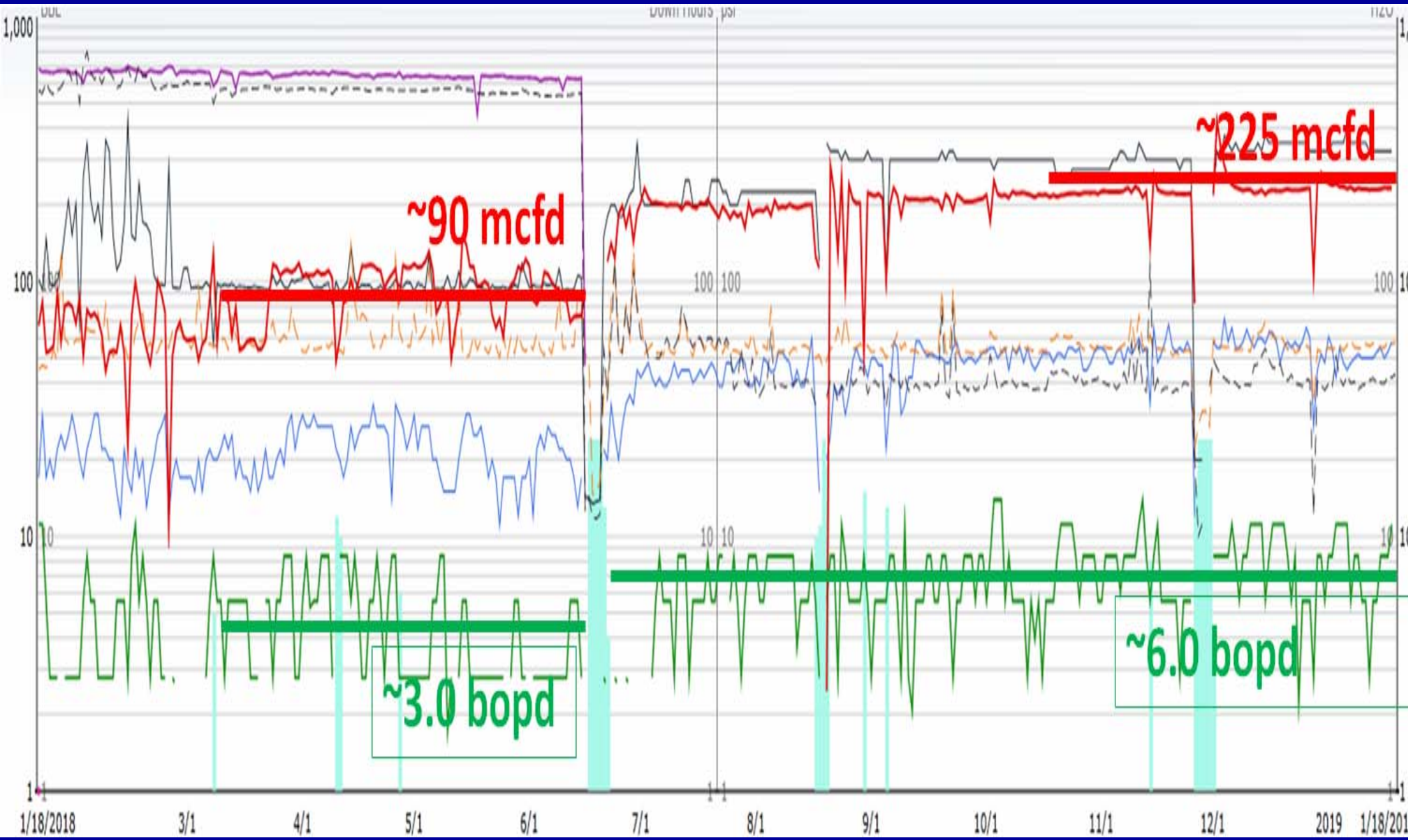




Oil = ------- Water = ------- Gas = -------

What's the Result?

UPS Well #2H: 4 MBO + 470 MMCF -------- (downdip well online +7 months)



Oil = ------- Water = ------- Gas = -------

Questions?

Brian.Ellithorp@echometer.com

405-837-0173

Simulation of Down-Hole Gas Separator Performance

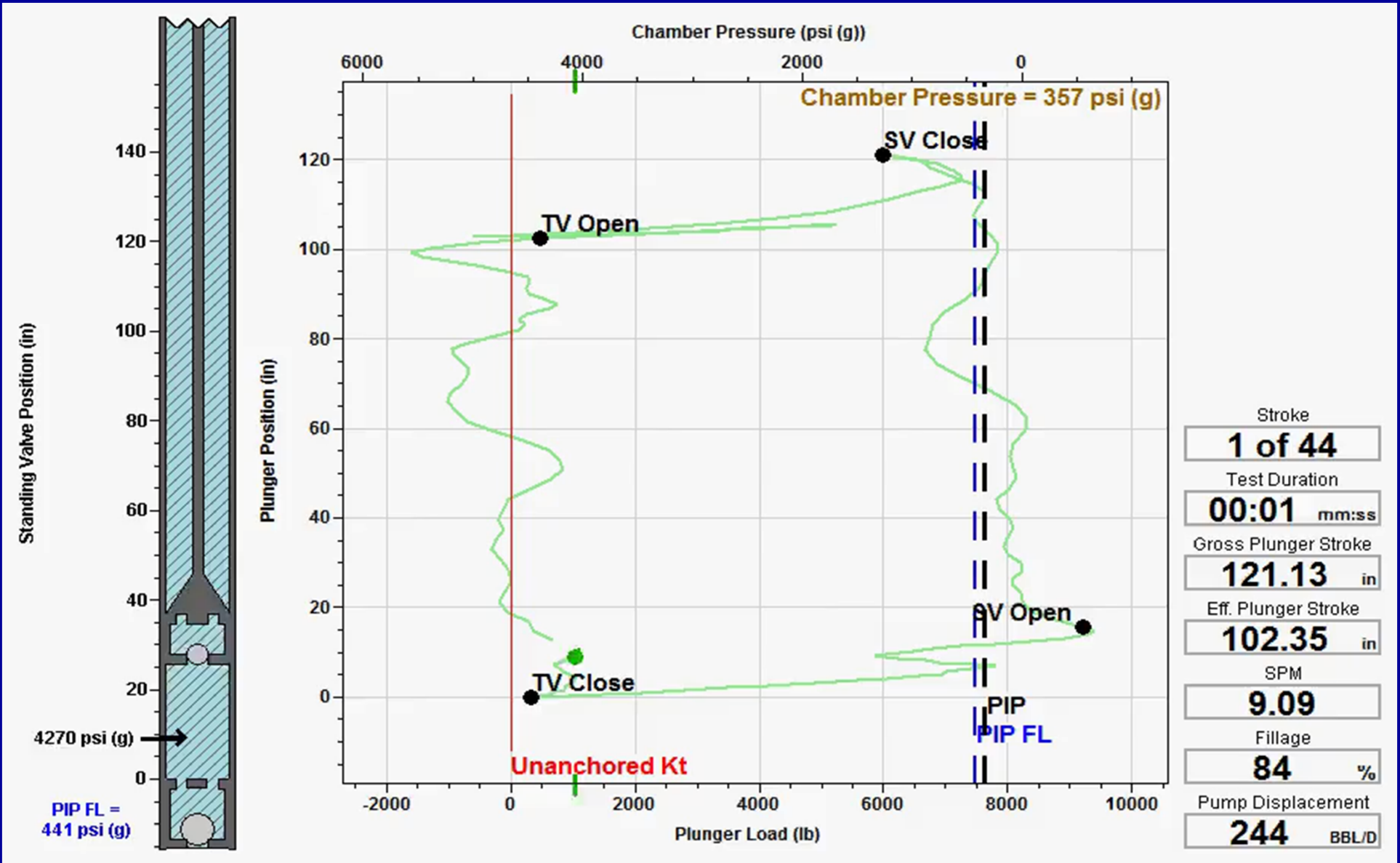
Gas Separator Simulation Software SWPSC 2014.pdf

(((ECHOMETER)))

Gas Separator Simulation Program

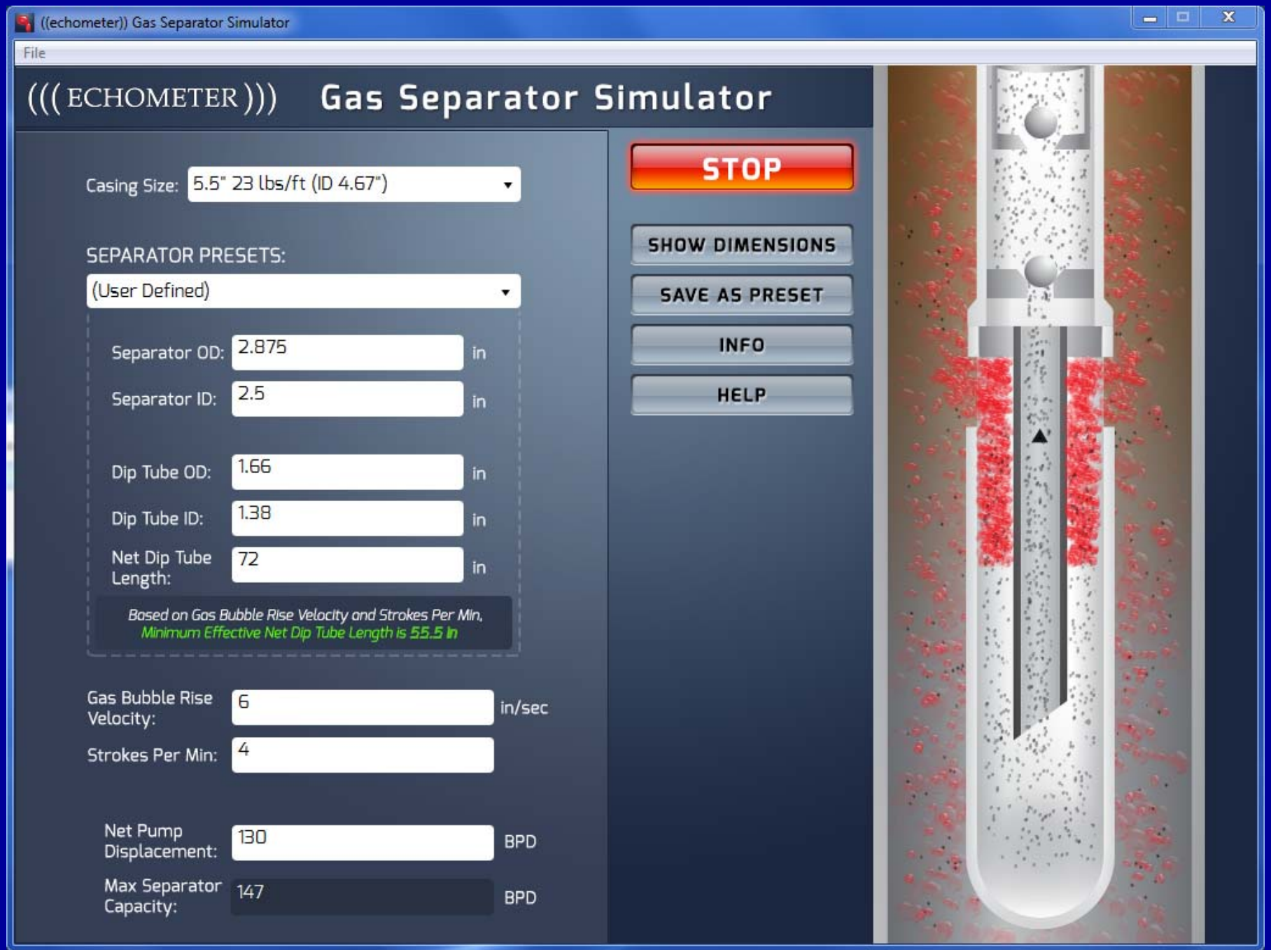
- Simulation program shows how a gas separator separates the liquid from the gas.
- Viewing the simulation should help operators understand how gas separators work and improve the results of the separators that they are running.
- Operators can analyze a particular separator configuration and view how the gas separator separates the liquid from the gas and also determine separator capacity.

Chamber Pressure Animation Shows Behavior of Fluids & Pump



Echometer Gas Separator Simulation Program

(Free to Download from Web)



Studies Performed at the University of Texas

Podio, Tony, J. N. McCoy, M. D. Woods, Hanne Nygard, and B. Drake, "Field and Laboratory Testing of a Decentralized Continuous-Flow Gas Anchor", Proceedings of the 46th Annual Technical Meeting of the Petroleum Society of CIM, 1995.

Guzman, M.: "Downhole Gas Separator Performance in Sucker Rod Pumping System," (master's thesis, University of Texas at Austin, 2005).

Lisigurski, O.: "The Effect of Geometry on the Efficiency of Downhole Gas Separators," (master's thesis, University of Texas at Austin, 2004).

Robles, J. and A. L. Podio, "Effect of Free Gas and Downhole Gas Separation Efficiency on the Volumetric Efficiency of Sucker Rod Pumps and Progressing Cavity Pumps," Proceedings of the 43rd Annual Meeting of the SWPSC, 1996.

R. Bohorquez, V. Ananaba, O. Alabi, A. L. Podio, O. Lisigurski, and M. Guzman, "Laboratory Testing of Downhole Gas Separators," SPE 109532

Videos can be viewed at

http://www.utexas.edu/ce/petex//aids/pubs/beamlift/toolbox/#downholeseparator

Variable Descriptions with Gas Flow Display

((echometer)) Gas Separator Simulator

File

(((ECHOMETER))) Gas Separator Simulator

Casing Size: 5.5" 23 lbs/ft (ID 4.67")

SEPARATOR PRESETS:

2 7/8" Poor Boy Separator

Separator OD: 2.875 in

Separator ID: 2.5 in

Dip Tube OD: 1.66 in

Dip Tube ID: 1.38 in

Net Dip Tube Length: 72 in

Based on Gas Bubble Rise Velocity and Strokes Per Min,
Minimum Effective Net Dip Tube Length is 55.5 in

Gas Bubble Rise Velocity: 6 in/sec

Strokes Per Min: 4

Net Pump Displacement: 130 BPD

Max Separator Capacity: 147 BPD

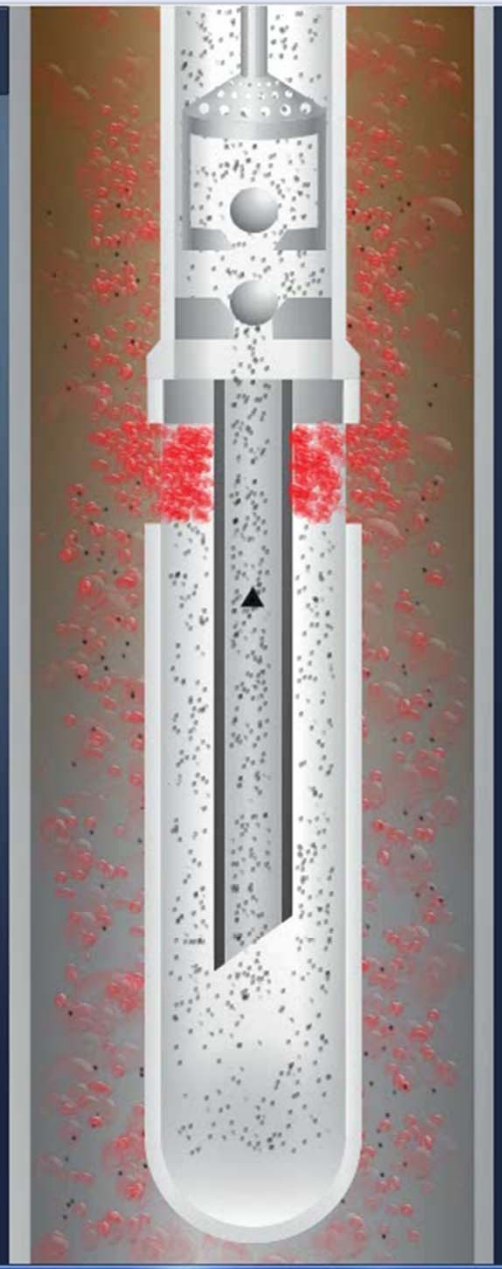
STOP

SHOW DIMENSIONS

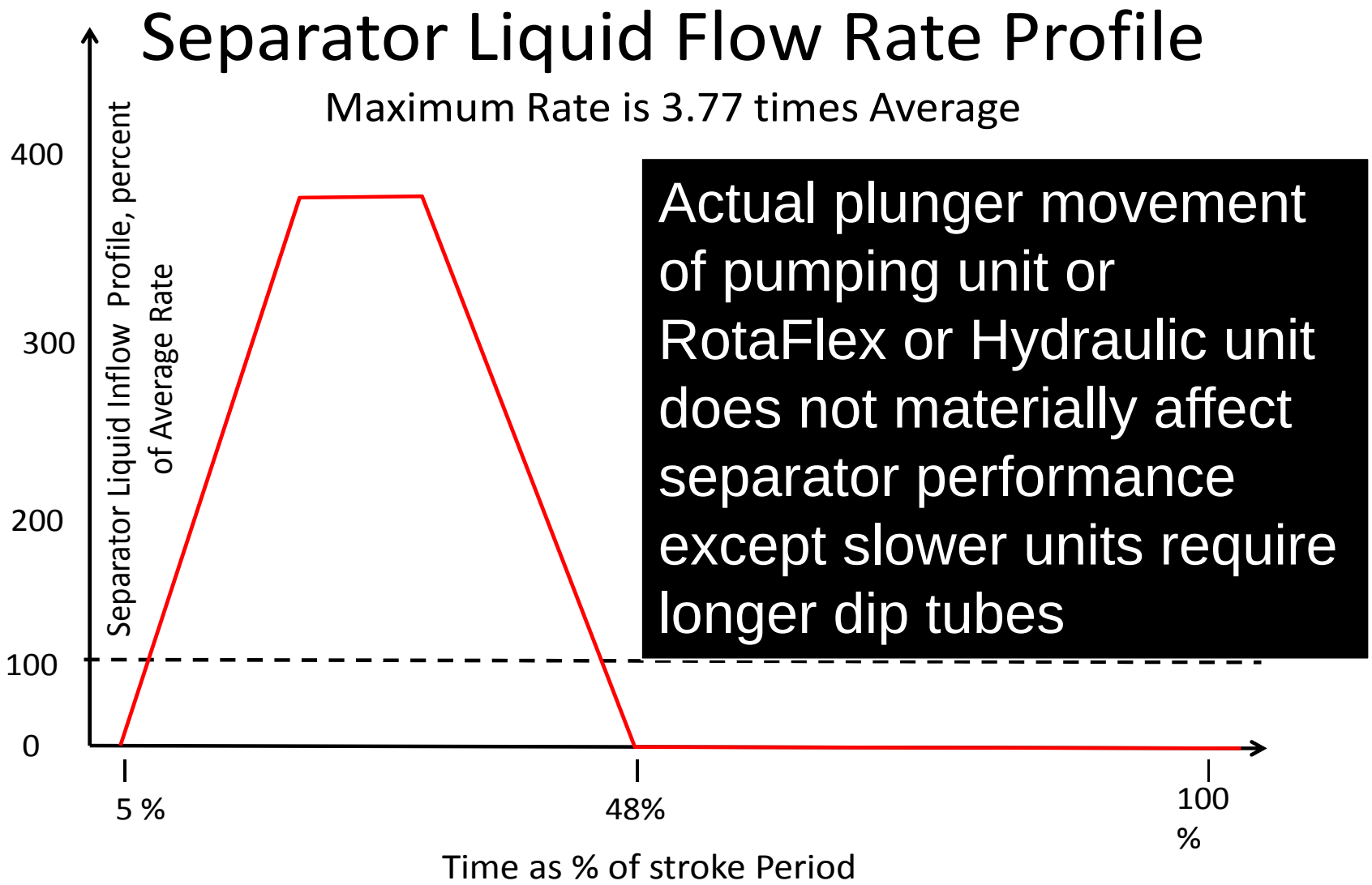
SAVE AS PRESET

INFO

HELP

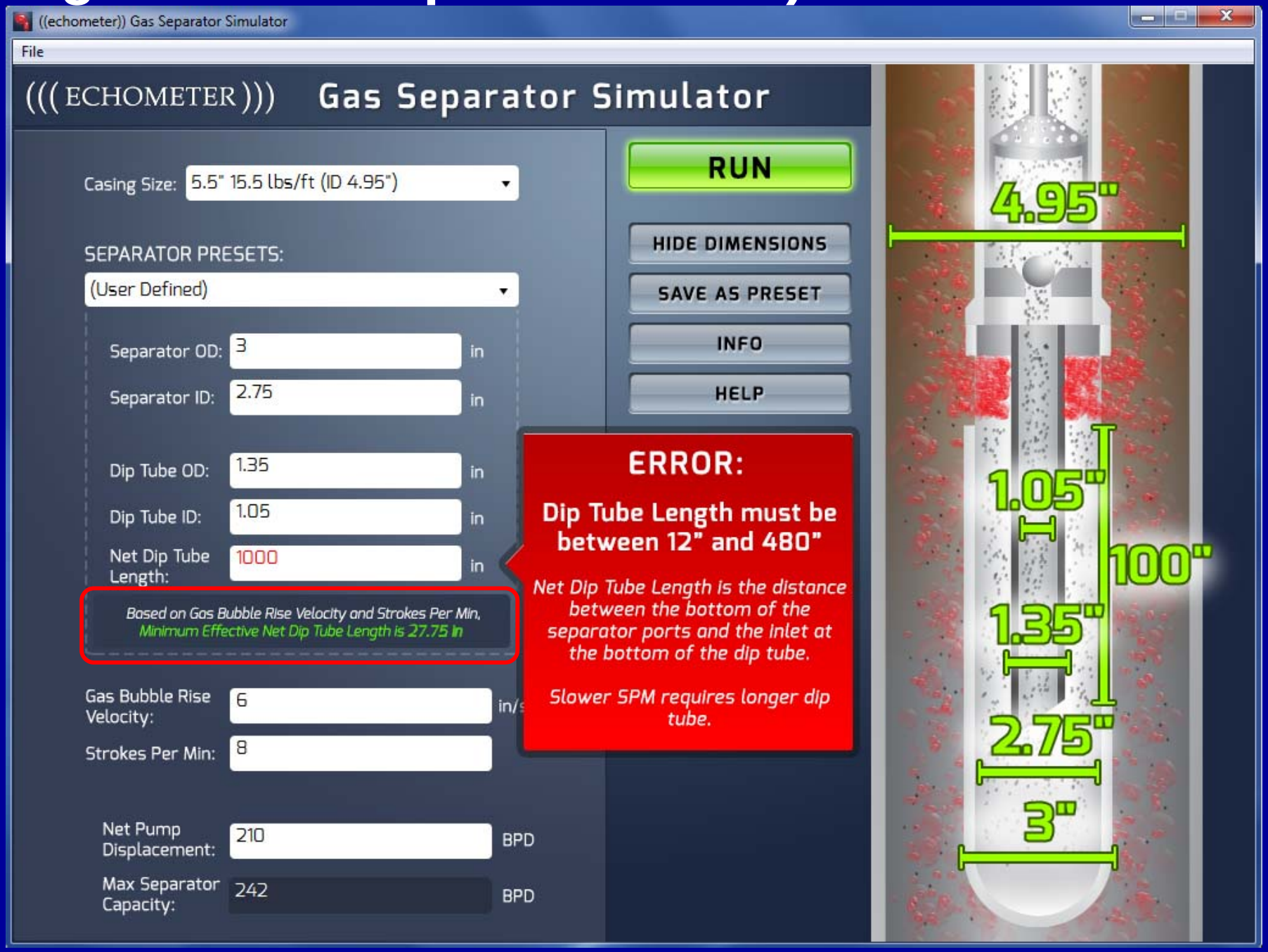


Net Pump Displacement Simulation



Actual plunger movement of pumping unit or RotaFlex or Hydraulic unit does not materially affect separator performance except slower units require longer dip tubes

Dip Tube Length
(Length Below Separator Ports)



Gas Movement

All gas that is in the separator below the inlet ports at the beginning of the upstroke will eventually move into the pump chamber. (Gas must EXIT on down stroke)

Gas separator capacity should exceed the net pump displacement rate so that gas bubbles will not exist in the separator annulus at the beginning of the upstroke.

Long dip tube in excess of the required net dip tube length does not increase the separation capacity of the separator. Added pressure drop hurts pump fillage by restricting liquid flow into the pump chamber.

Maximum Gas Separator Capacity Performance

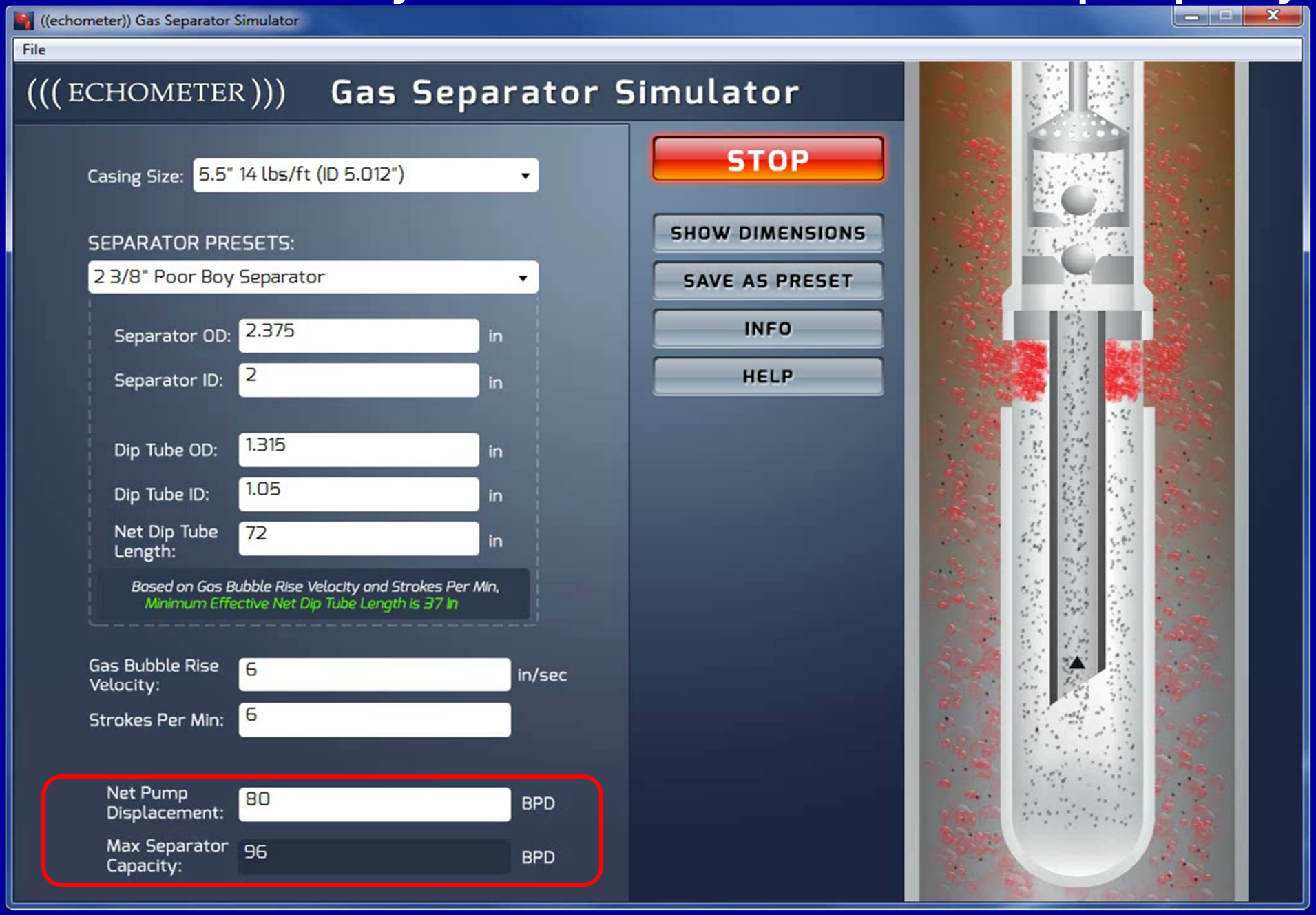
Operating a gas separator with a net pump displacement in excess of gas separator capacity will cause gas to be pulled into the pump.

Run the simulation program shown in the next slide at the recommended pump displacement rates.

Generally, the pump will be about 25-40 % filled with liquid if the pump displacement exceeds the gas separator capacity excessively.

Maximum Capacity Behavior

Run a 2 3/8 Poor boy at 80 and 96 and 120 BPD Pump Capacity



Simulation Program to Field Tests Comparison

- Simulation program predicts how a separator will perform in the field so that the proper gas separator and pump can be selected.

- Field tests will be compared to the simulation program to determine what bubble rise velocity should be used in that particular field.

- Industry uses 6 inches/second for the bubble rise velocity. Is this the correct rise velocity?

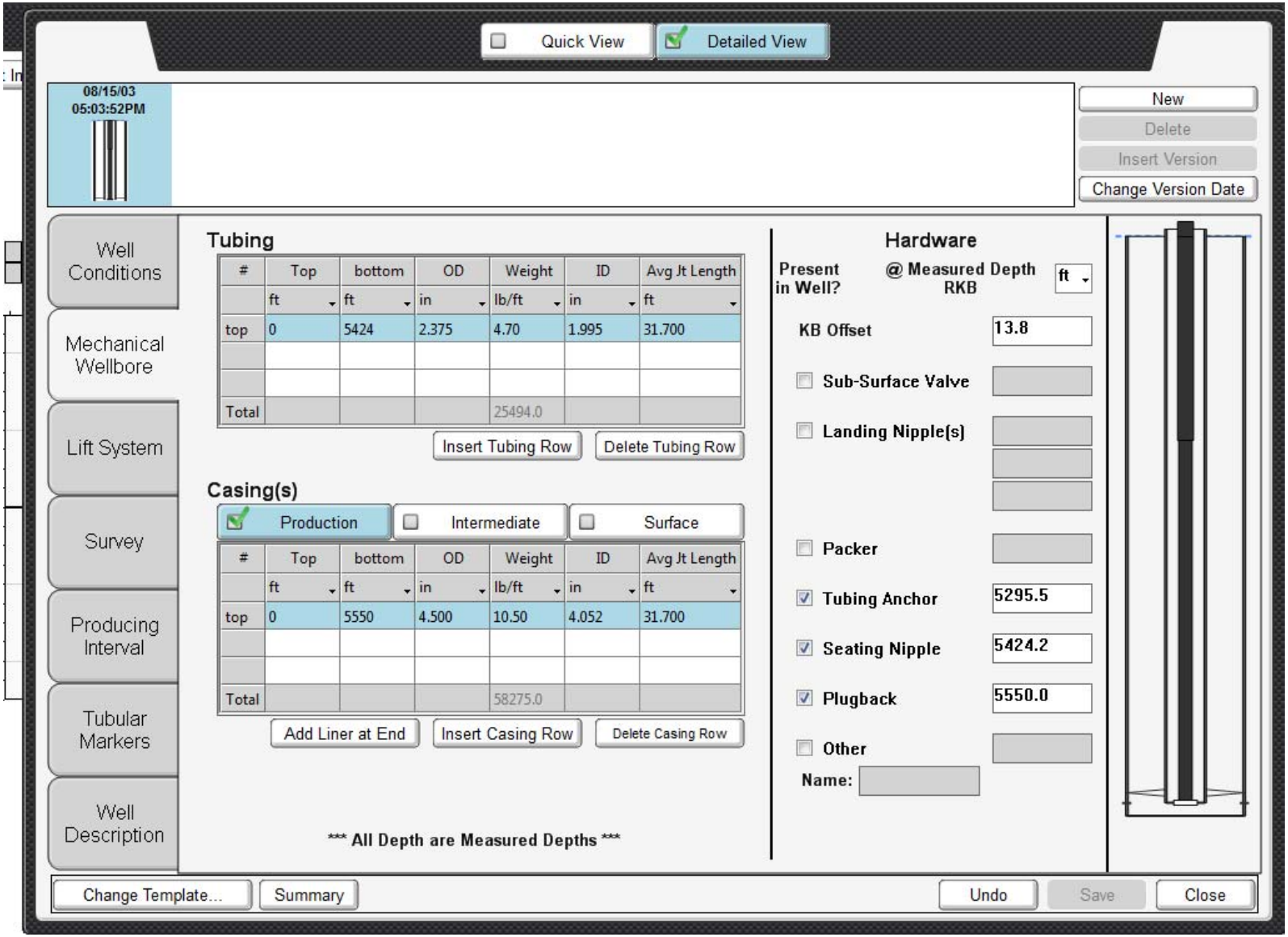
Gas Separator Sizing - Workbook

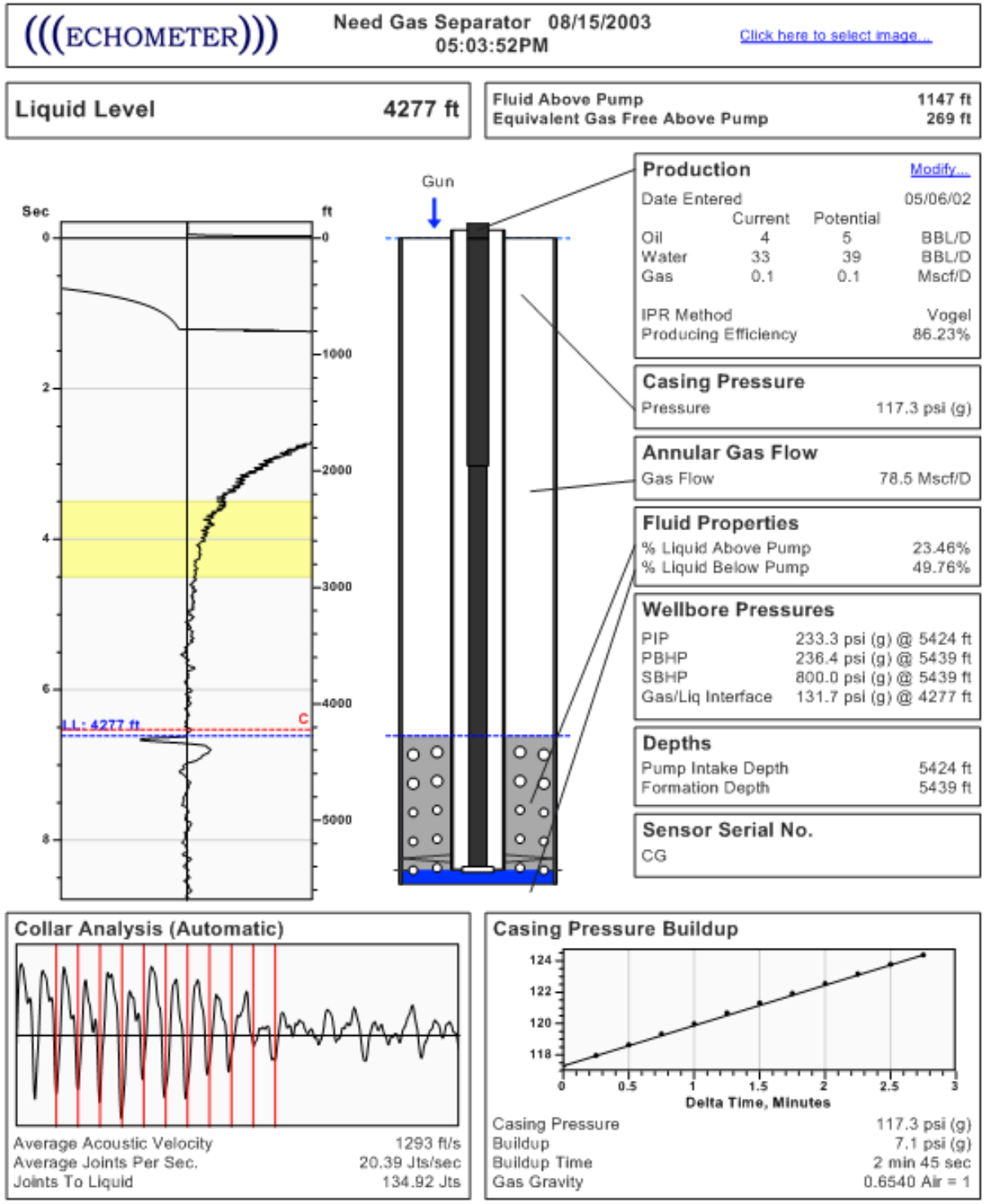
1. Select a well where gas interference is a problem.
2. Review fluid level and dynamometer analyses and note:
   - Height of gaseous column above pump, ft
   - Percent gas at pump intake
   - Annular gas flow rate, MCF/D
   - Pump liquid fillage %
   - Effective and maximum pump displacements, BPD
   - Pumping speed (SPM)
   - Casing and tubing sizes, ID and OD
3. Input data in Separator Simulator.
4. Try different types of separators that will fit inside casing.
5. Select separator that has a liquid capacity greater than the maximum pump displacement at the given SPM.
6. Run simulator and verify that gas does not reach pump intake.

Example No. 1 4-1/2 in. Casing

- Following well data and records are from the TAM example well “Needs Gas Separator”
  - Pump set above the perforations
  - Medium height annular gaseous column
  - Annular gas flow
  - Gas-Liquid mixture at pump intake
  - Small diameter casing
  - Limited rat hole
  - Gas engine slowed to minimum SPM

Wellbore: 4-1/2” Casing 2-3/8” Tubing





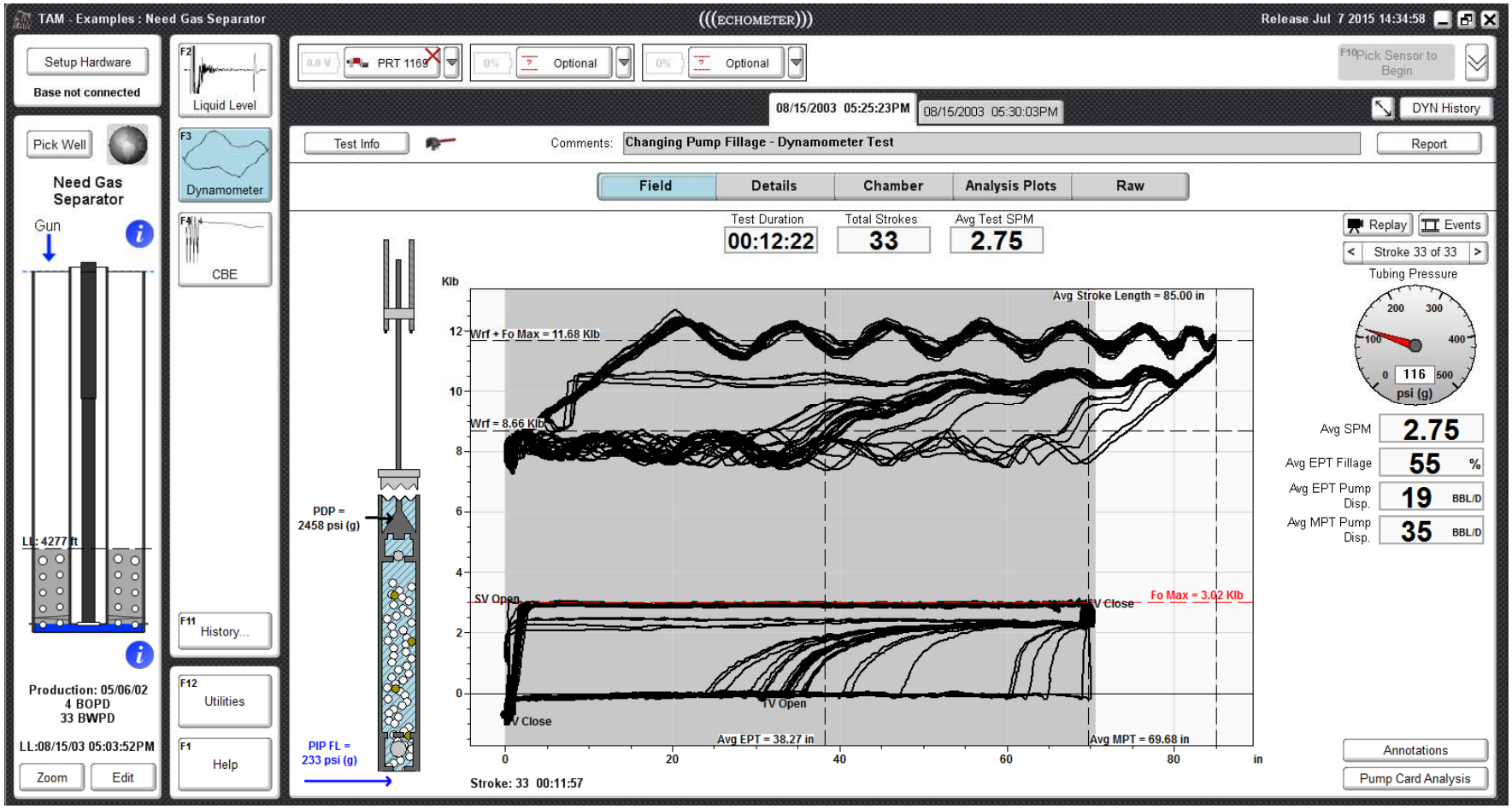
Annular gas flow:
78.5 MSCF/D

Liquid at pump intake:
23.45 %

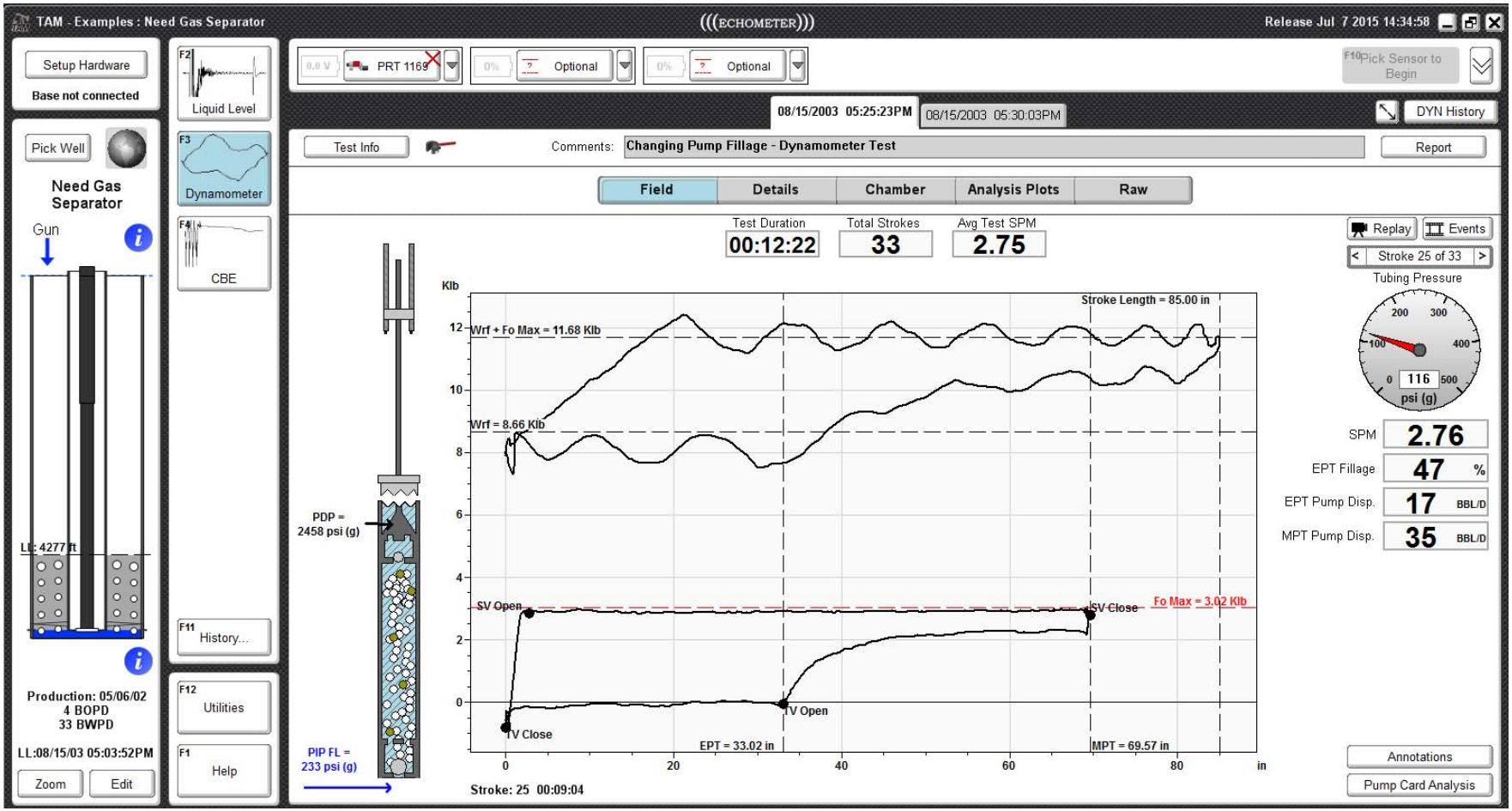
Pump intake pressure:
233 psi

Oil vs Water Rate:
10% Oil

Dynamometer Record for 33 Strokes
Liquid fillage varies from 20 to 70%



Typical Pump Performance @ 2.76 SPM
Maximum Plunger Displacement = 35 BPD



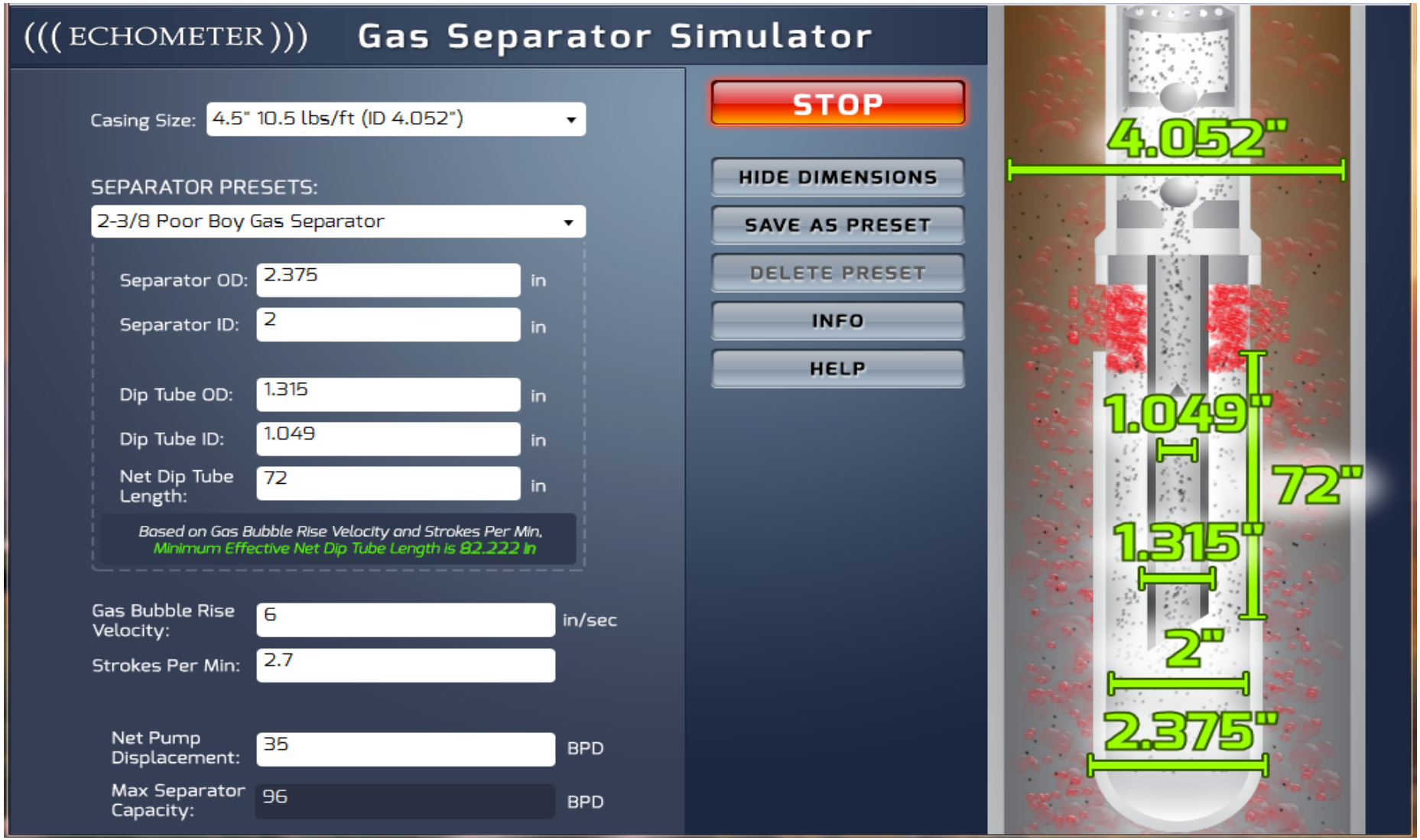
What Kind of Separator is Needed?

1 - Must fit inside 4-1/2 inch casing 10.5 #/ft
2 - Must have a liquid capacity greater than 35 BBL/D
3 - Must have a gas capacity greater than 75 MSCF/D
4 - Solids production is not a problem
5 - Should be simple and inexpensive

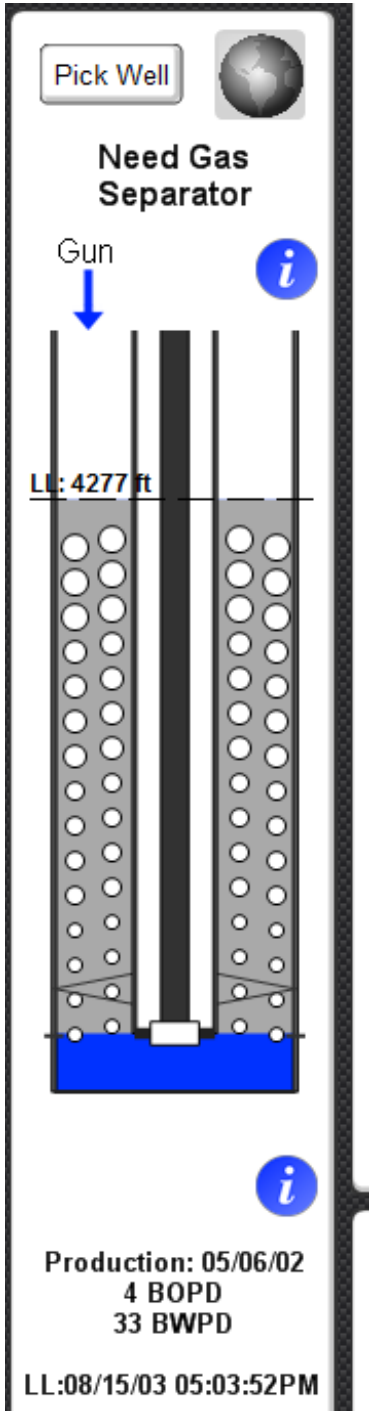
<u>Possible choices</u>

Since liquid flow rate is less than 50 BPD one should consider a conventional “Poor-boy” separator as shown in following slide. Is 6 “/Sec gas bubble rise OK?

1. Open Echometer's Separator Simulator Application and enter Casing size, SPM and Pump displacement.
2. Initially choose the 2-3/8 Poor Boy
3. Click RUN to observe performance.



Simulator computes the separator maximum capacity as 96 BPD which exceeds the pump rate of 35 BPD. The Poor-boy separator built as shown in the dimensional diagram should perform OK for this low liquid rate application.



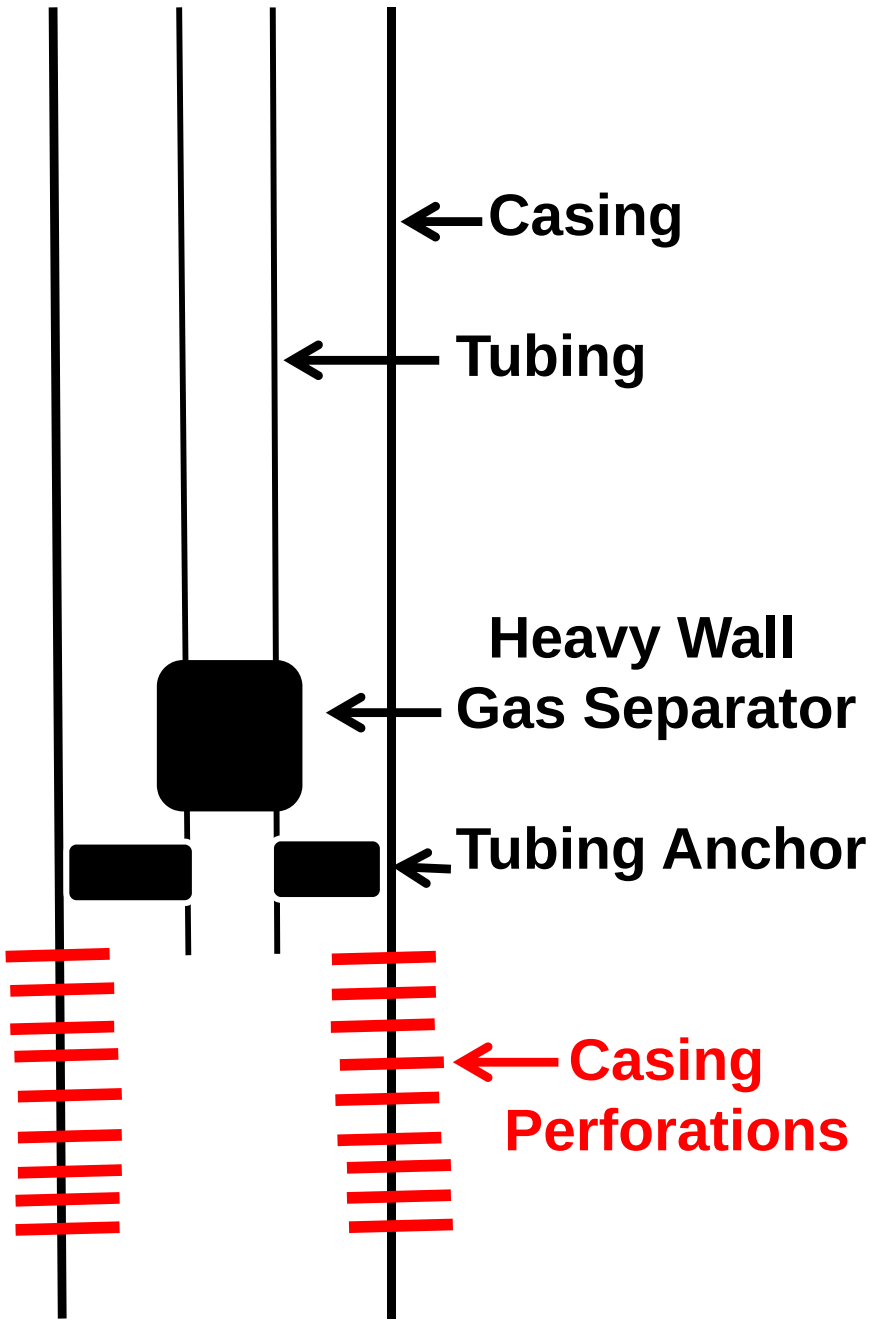
Possible Gas Interference Problem Caused by Tubing Anchor

Note that in this well the 2-3/8 inch tubing is anchored inside the 4-1/2 inch casing at a depth of 5295 ft or about 4 pipe joints above the pump intake.

The reduction in annular area caused by the presence of the TA body and slips could create a choking mechanism and cause a high concentration of gas below the TA and prevent the liquid in the gaseous column to fall to the pump intake.

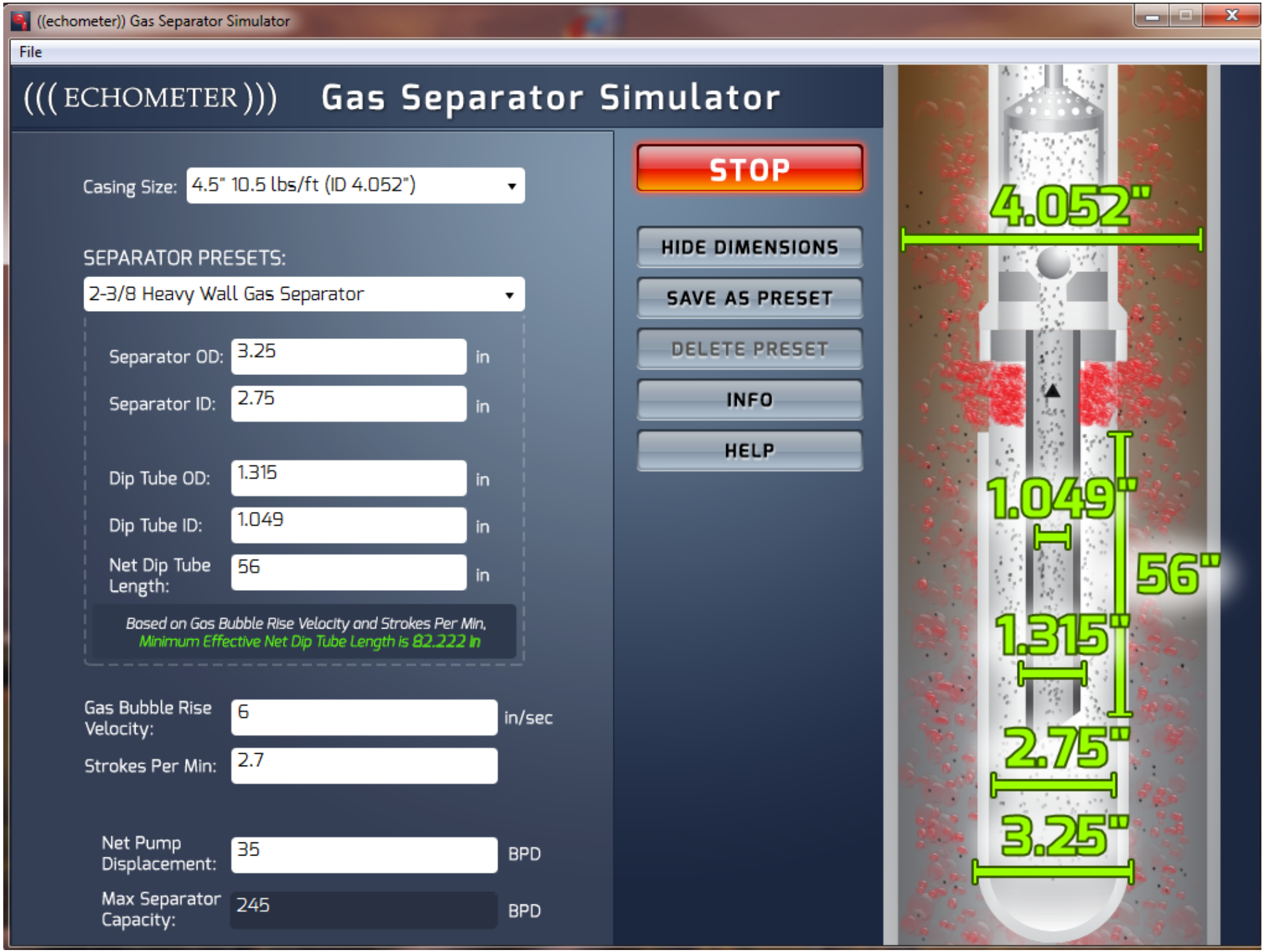
This well may be a candidate for using a heavy wall separator located above the Tubing anchor, as shown in the following slide

Heavy Wall Separator Above Tubing Anchor



Heavy wall collar size separator is above the tubing anchor and the casing perforations.

Heavy Wall Separator



Example No. 2 7-5/8 in. Casing

- Following well data and records
  - Pump set above the perforations
  - Medium height annular gaseous column
  - Annular gas flow
  - Gas-Liquid mixture at pump intake
  - Large diameter casing
  - Limited rat hole
  - Electric Motor 12 hour run time

Wellbore: 7-5/8” Casing 2-3/8” Tubing

Quick View | Detailed View

01/21/14
01:33:51PM

New
Delete
Insert Version
Change Version Date

Well Conditions
Mechanical Wellbore
Lift System
Survey
Producing Interval
Tubular Markers
Well Description

Tubing

#	Top	bottom	OD	Weight	ID	Avg. Jt Length
	ft	ft	in	lb/ft	in	ft
top	0	8092	2.375	4.70	1.995	31.800
Total				38032.4		

Insert Tubing Row | Delete Tubing Row

Casing(s)

Production | Intermediate | Surface

#	Top	bottom	OD	Weight	ID	Avg. Jt Le...
	ft	ft	in	lb/ft	in	ft
top	0	8200	7.625	24.00	7.025	31.700
Total				196800.0		

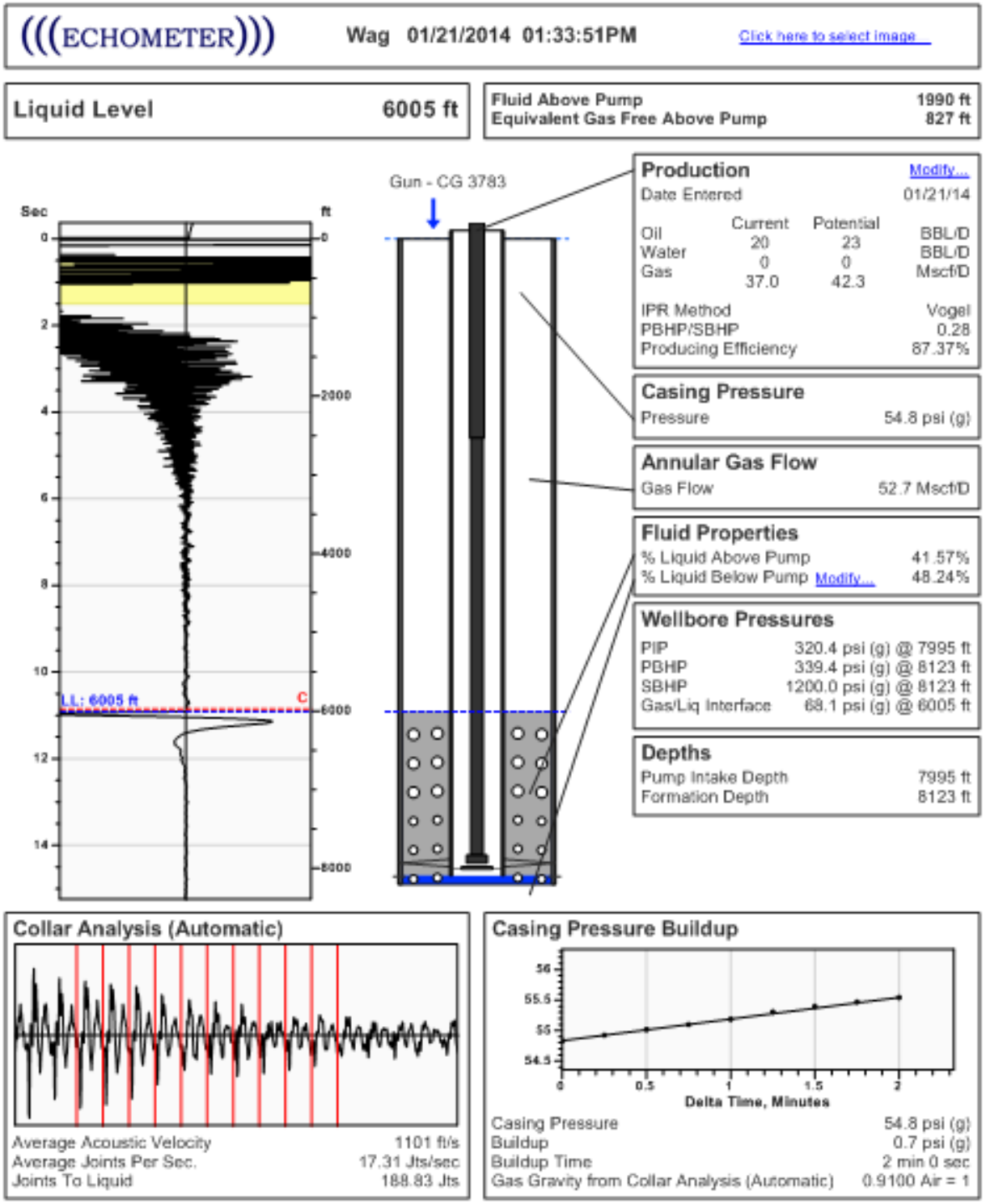
Add Liner at End | Insert Casing Row | Delete Casing Row

*** All Depth are Measured Depths ***

Hardware

Present in Well?		@ Measured Depth RKB (ft)
	KB Offset	20.0
☐	Sub-Surface Valve	
☐	Landing Nipple(s)	
☐	Packer	
☐	Bridge Plug	
☑	Tubing Anchor	7931.0
☑	Seating Nipple	7995.0
☑	Plugback	8200.0
☐	Other	
	Name:	

Change Template... | Summary | Undo | Save | Close



Annular gas flow:
52.7 MSCF/D

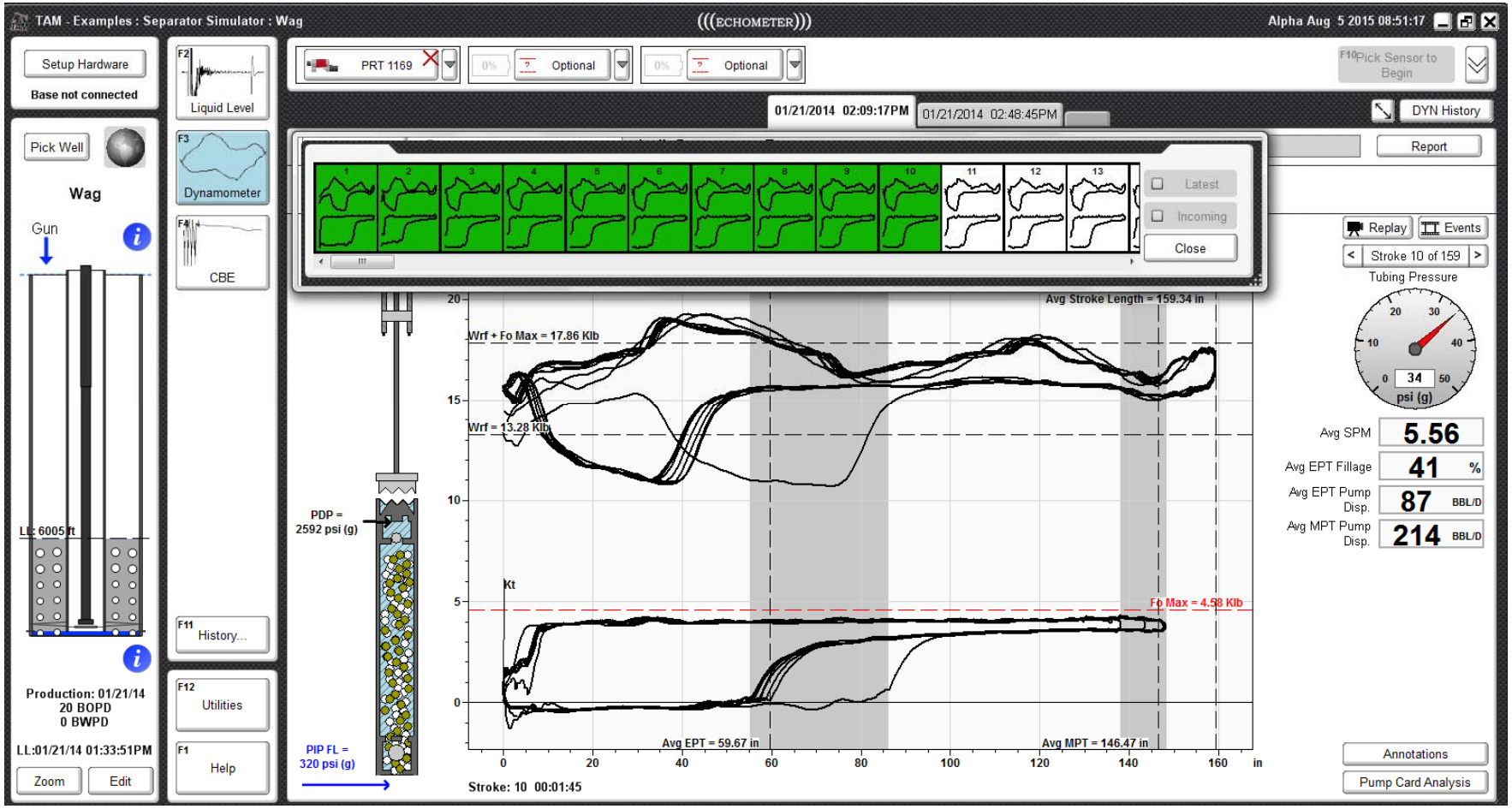
Liquid at pump intake:
41.57 %

Pump intake pressure:
320 psi

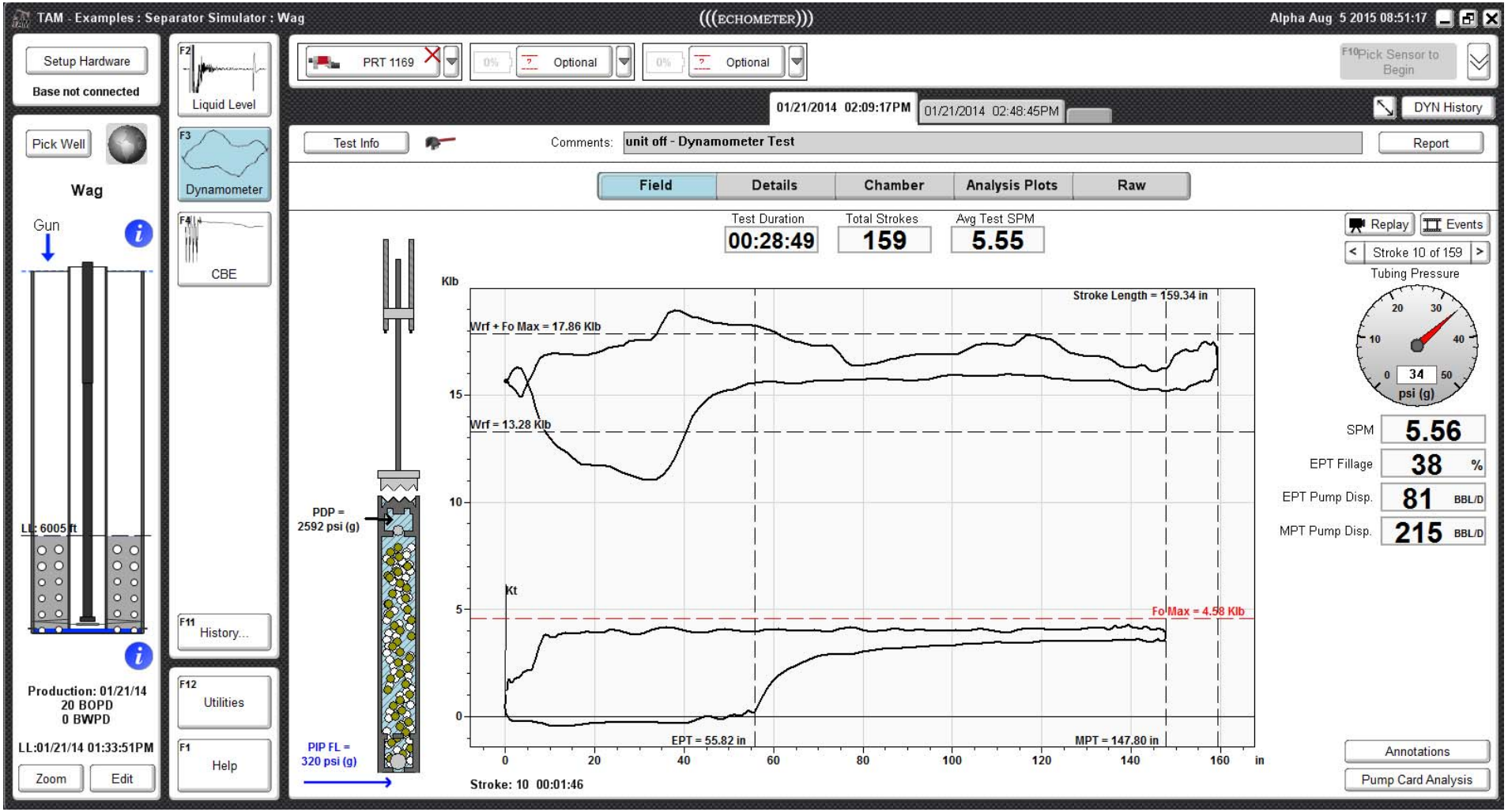
Oil vs Water Rate:
100% Oil
(consider using Gas bubble rise of 2”/sec!)

Dynamometer Record for 10 Strokes

After first stroke liquid fillage stabilizes at 41%



Typical Pump Performance @ 5.56 SPM
Maximum Plunger Displacement = 215 BPD



TAM - Echometer Online : GasSeparatorPerformance_18 : Wag

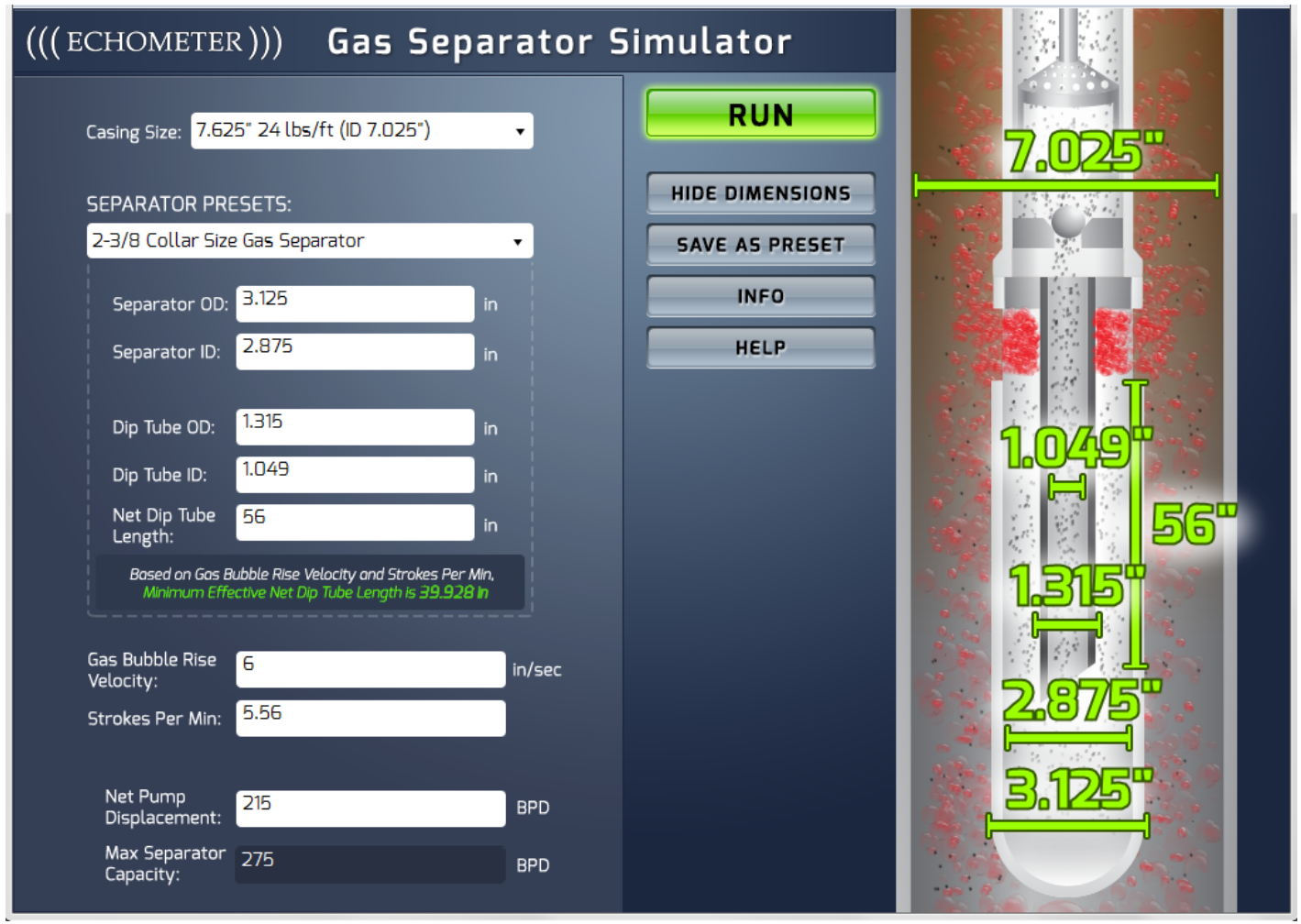
What Kind of Separator is Needed?

1 - Must fit inside 7-5/8 inch casing 24 #/ft
2 - Must have a liquid capacity greater than 215 BBL/D
3 - Must have a gas capacity greater than 53 MSCF/D
4 - Solids production is not a problem
5 - Should be simple and inexpensive

<u>Possible choices</u>

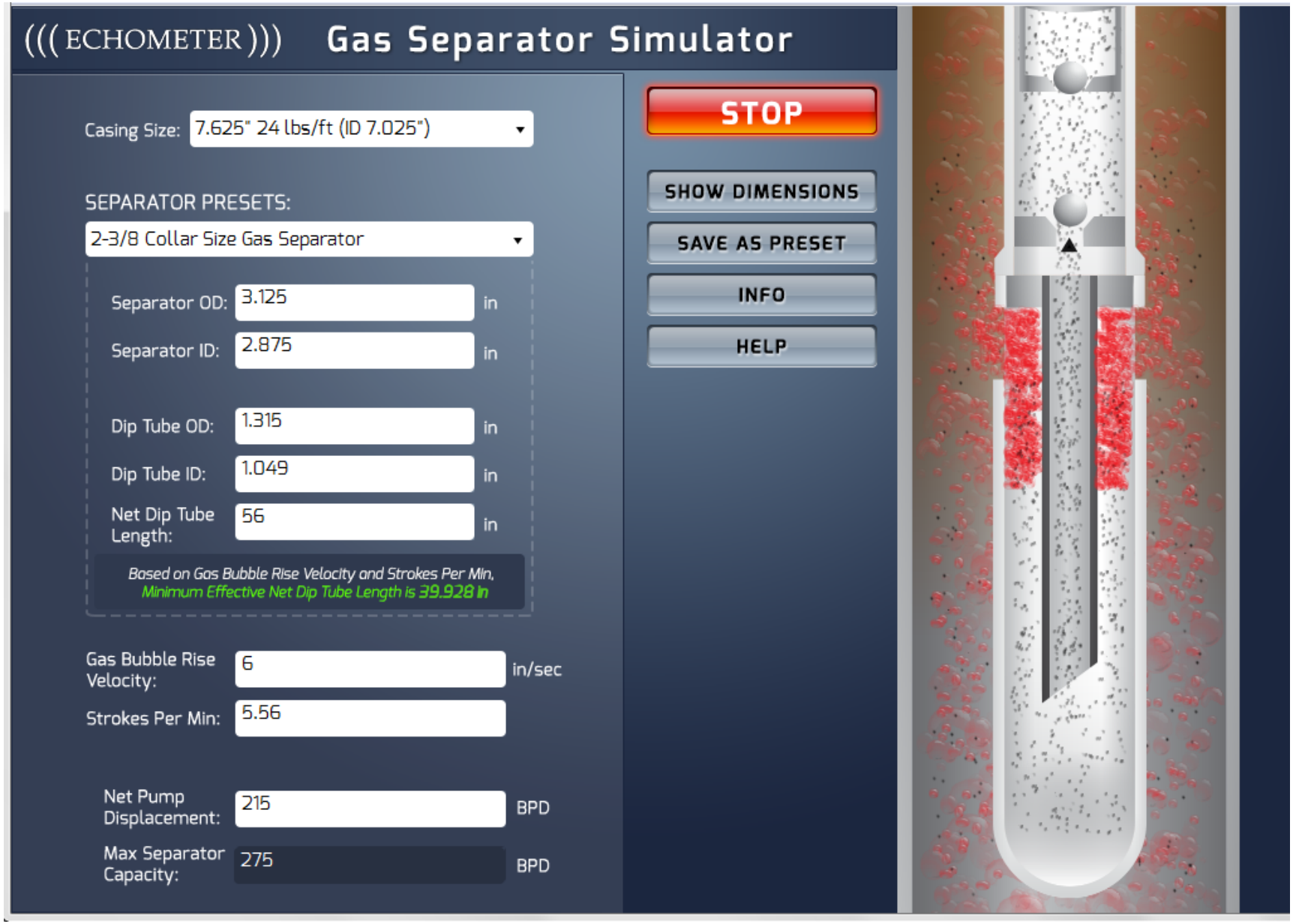
Numerous, since casing size is not a limitation. Try 2-3/8” collar size for initial choice.

1. Open Echometer's Separator Simulator Application and enter Casing size, SPM and Pump displacement.
2. Initially choose the 2-3/8 Collar size
3. Click RUN to observe performance.



Simulator computes the separator maximum capacity as 275 BPD which exceeds the pump rate of 215 BPD. The Collar Size separator built as shown in the dimensional diagram should perform OK for this liquid rate application.

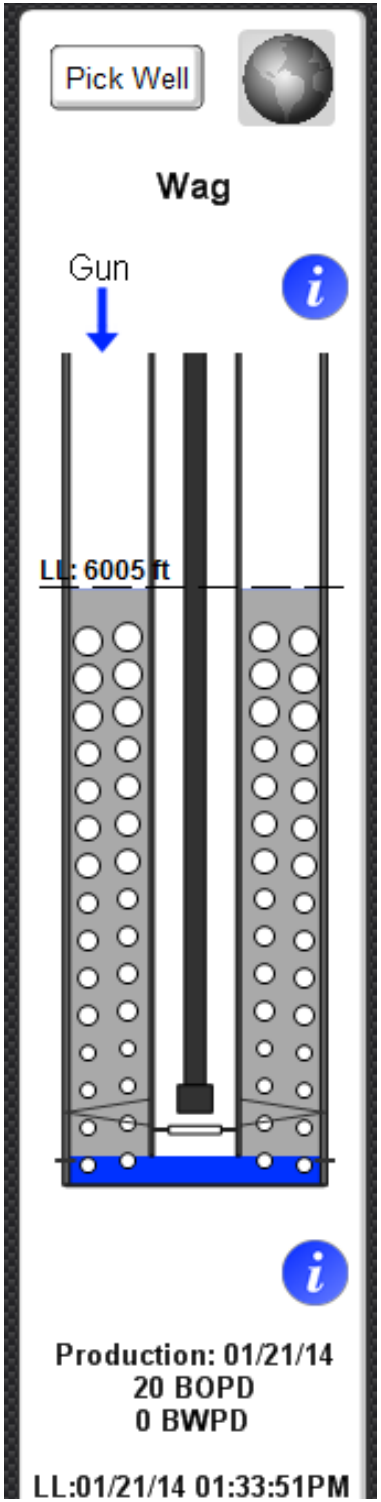
Verification of Performance – OK if 6”/sec gas bubble rise – water and air



During plunger upstroke the gas/liquid interface in the separator annulus drops to about mid point of separator but never reaches the entrance to the dip tube.

Performance – if 2”/sec gas bubble rise – Need Much Larger Gas Separator

During plunger upstroke the gas/liquid interface in the separator annulus drops to about mid point of separator but never reaches the entrance to the dip tube.



Unlikely Gas Interference Problem Caused by Tubing Anchor

Note that in this well the 2-3/8 inch tubing is anchored inside the 7-5/8 inch casing at a depth of 7931 ft or about 5 pipe joints above the pump intake.

The presence of the TA body and slips in the large (34.3 sq. Inch) casing annular area is not likely to act as a choke and prevent the liquid in the gaseous column to fall to the pump intake considering the relatively low annular gas flow rate of 53 MSCF/D.

Final

This presentation and other presentations in addition to downhole pump animations showing gas compression, pump chamber pressure and pump fillage and also descriptive papers on the different gas separators discussed are available from Echometer Company.

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Videos of gas/liquid separation in laboratory models can be obtained at the University of Texas website

http://www.utexas.edu/ce/petex//aids/pubs/beamlift/toolbox/#downholeseparator