Ask Echometer Online Seminar – June 24, 2020

(((ECHOMETER)))

How Much Liquid Does My Sucker Rod Pump PUMP ?

TOTAL ASSET MONITOR (TAM)

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

"USE OF THE PUMP SLIPPAGE EQUATION TO DESIGN PUMP CLEARANCES", Rowlan, McCoy, Lea, SWPSC 2012

"EQUIVALENT GAS FREE PUMP FILLAGE LINE", Rowlan, McCoy, Taylor, Brown, SWPSC 2015

"QRod Design Program WWW.ECHOMETER.COM Download, http://www.echometer.com/Software/QRod

"EXCEL Spreadsheets: Pump Slippage Calculator_SPM_PattersonEq.xls & SlippageViscosityCalculator.xls

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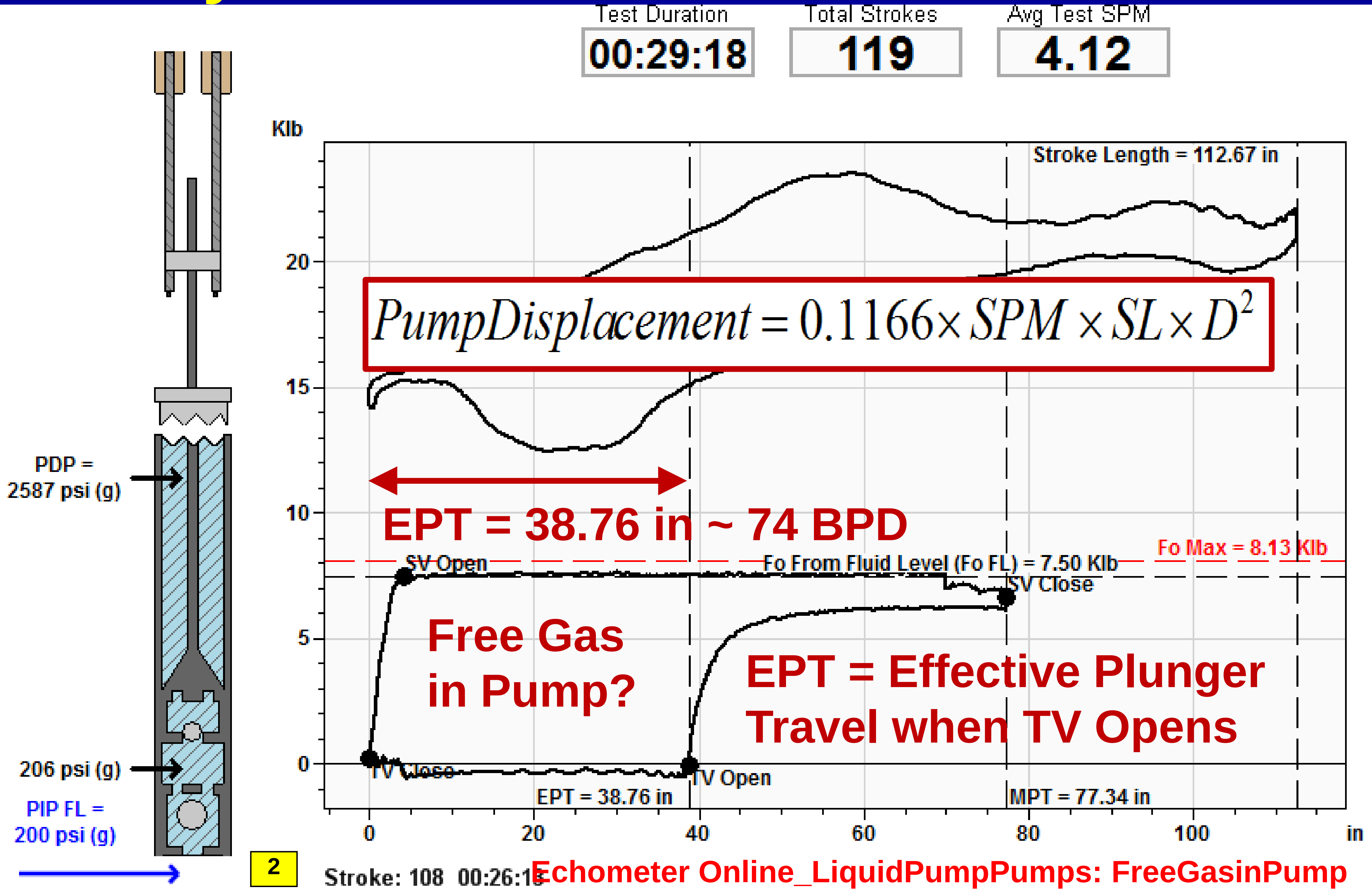
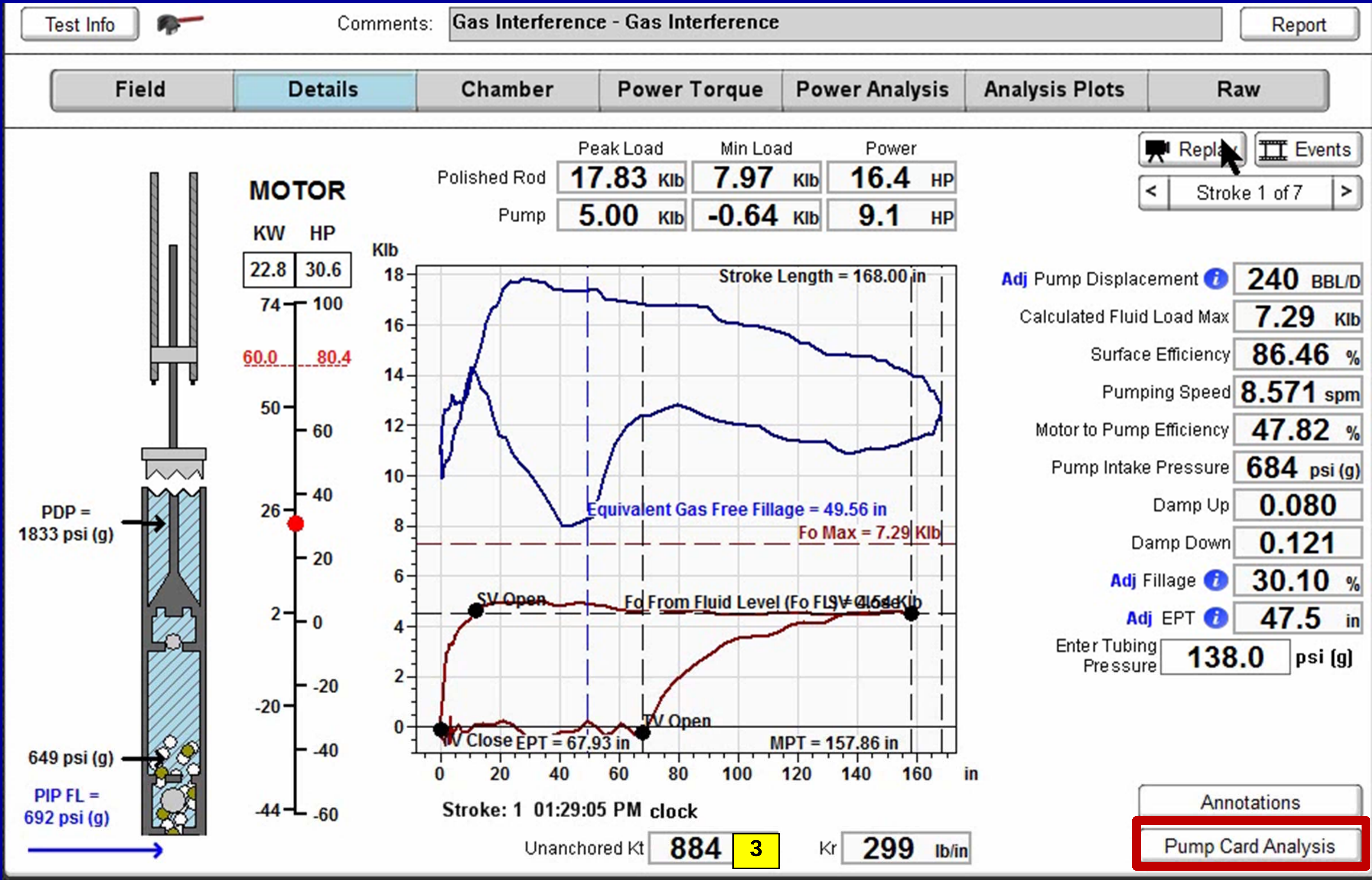
Why is Pump Displacement 74 BPD and Only 59 BPD Produced into the Tank



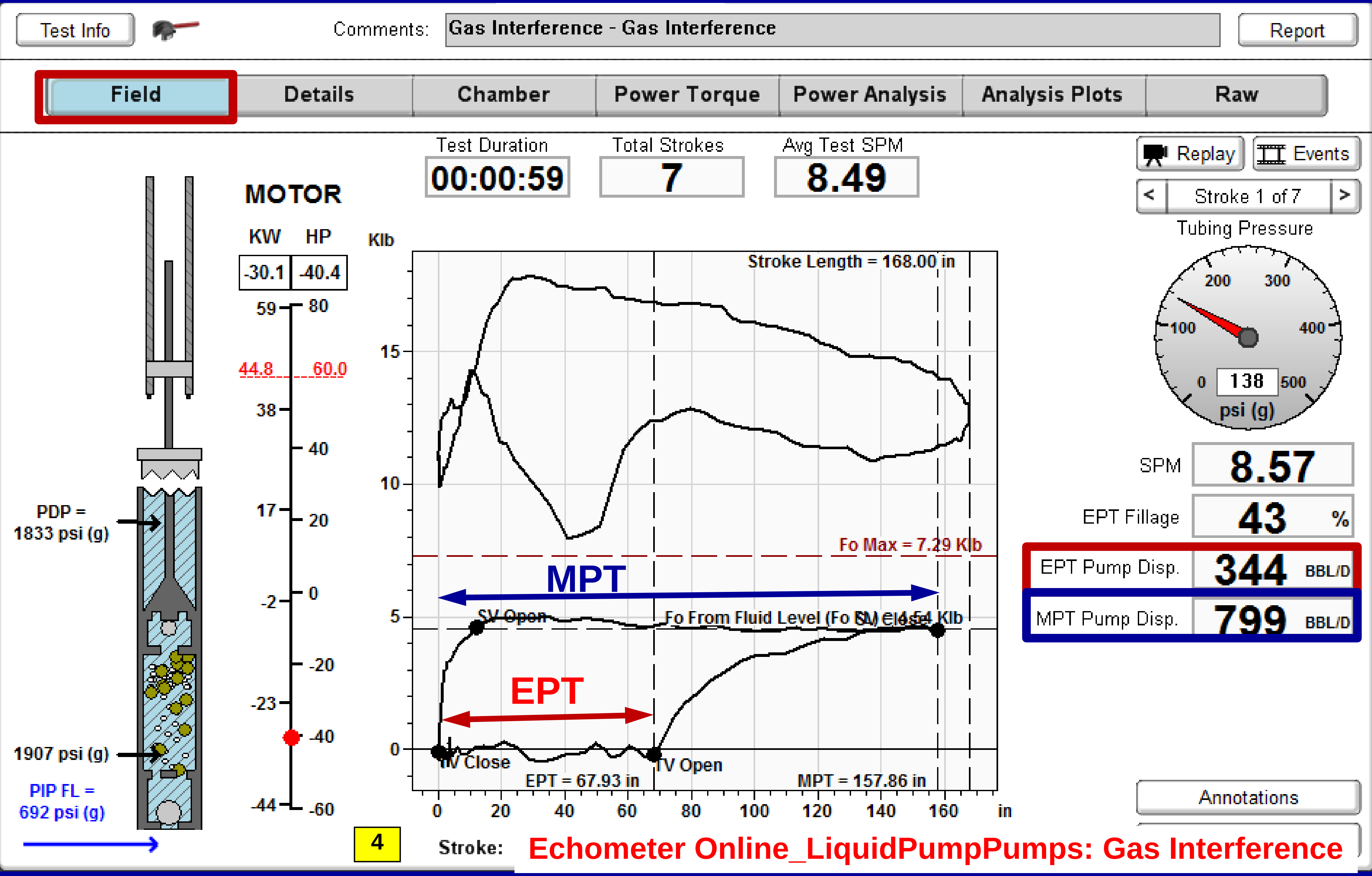
$$PumpDisplacement = 0.1166 \times SPM \times SL \times D^2$$

Echometer Online_LiquidPumpPumps: FreeGasinPump

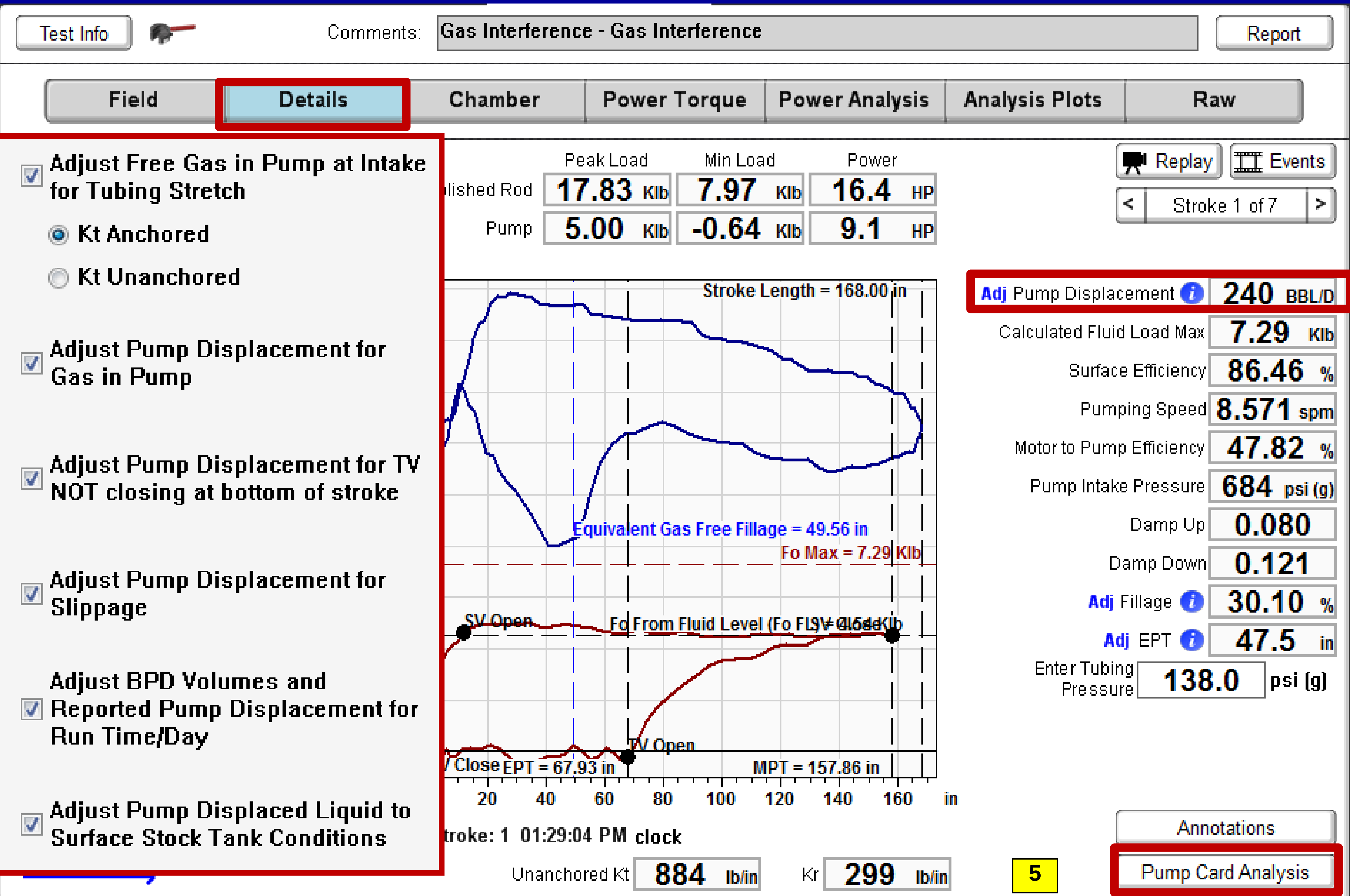
Determine the Amount of Stock Tank Oil and Water Contained in 1 Pump Stroke



Incorrect to Assume Pump Filled with Liquid: TV Open (EPT) OR Max Plunger Travel (MPT)



Adj Pump Displacement for a Selected Stroke



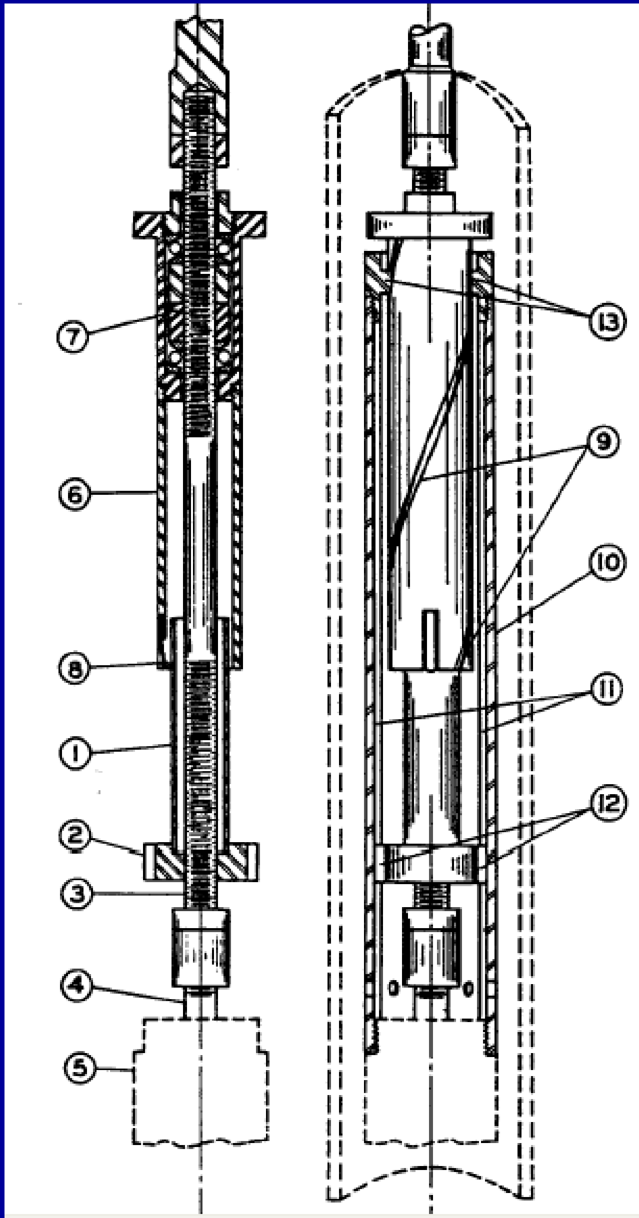
Introduction

- Determining the Amount of Stock Tank Oil and Water Contained in 1 Pump Stroke Requires the Use of Enhanced Analysis Techniques
- First Step is to Correctly Describe the Existing Wellbore and Artificial Lift System Configuration.
- Accurate and Representative Oil and Water Rates are used to determine % Oil
- Gravities are Used to Calculate Produced Fluid Behavior Inside the Pump Chamber During a Selected Pump Stroke.
- Once Traveling and Standing Valve Opening/Closing Points are Identified, then the Behavior of the Fluids Inside the Pump Chamber can be Modeled.

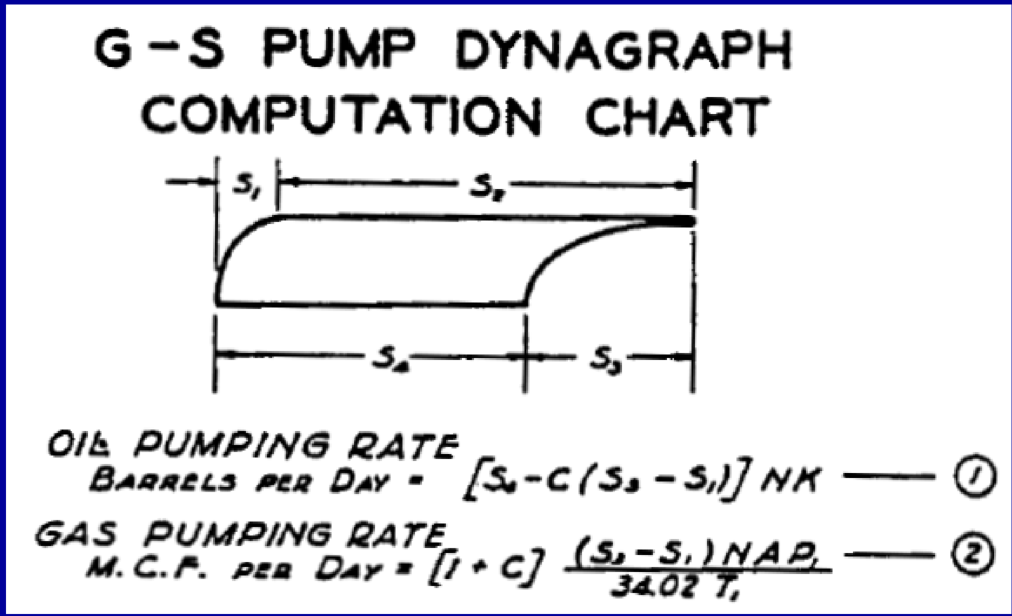
Introduction (continued)

- Tubing Pressure, Tubing Fluid Gradient and Deviation Survey are Required to Determine the Pump Discharge Pressure
- During the gas compression process no free gas goes is assumed to go into solution
- Fluids inside the pump assumed to remain at pump depth temperature
- Free Gas Inside the Pump at Intake conditions is Compressed to a Smaller Volume to the Discharge Pressure to Open the Travelling Valve
- Estimate 10% Oil if no Production Rates Entered
- SPM and Plunger Diameter are used in Determining BPD

W.E. Gilbert of Shell an Early Pioneer in the Interpretation of Pump Dynagraphs (1936)



1. Developed Bottomhole Instrument to Record Down-hole Action of Pump
2. Interpretation of Dynagraph Cards
3. In Appendix Developed Formulas to Calculate Intake Liquid and Gas Volumes in Pump Chamber and Compressed to Discharge



These type of calculations have been published by Lea, Sandia, TUALP, Gibbs\Nolan and others.

"An Oil-Well Pump Dynagraph", P. 107 W. E. Gilbert, Production Practice, 1936

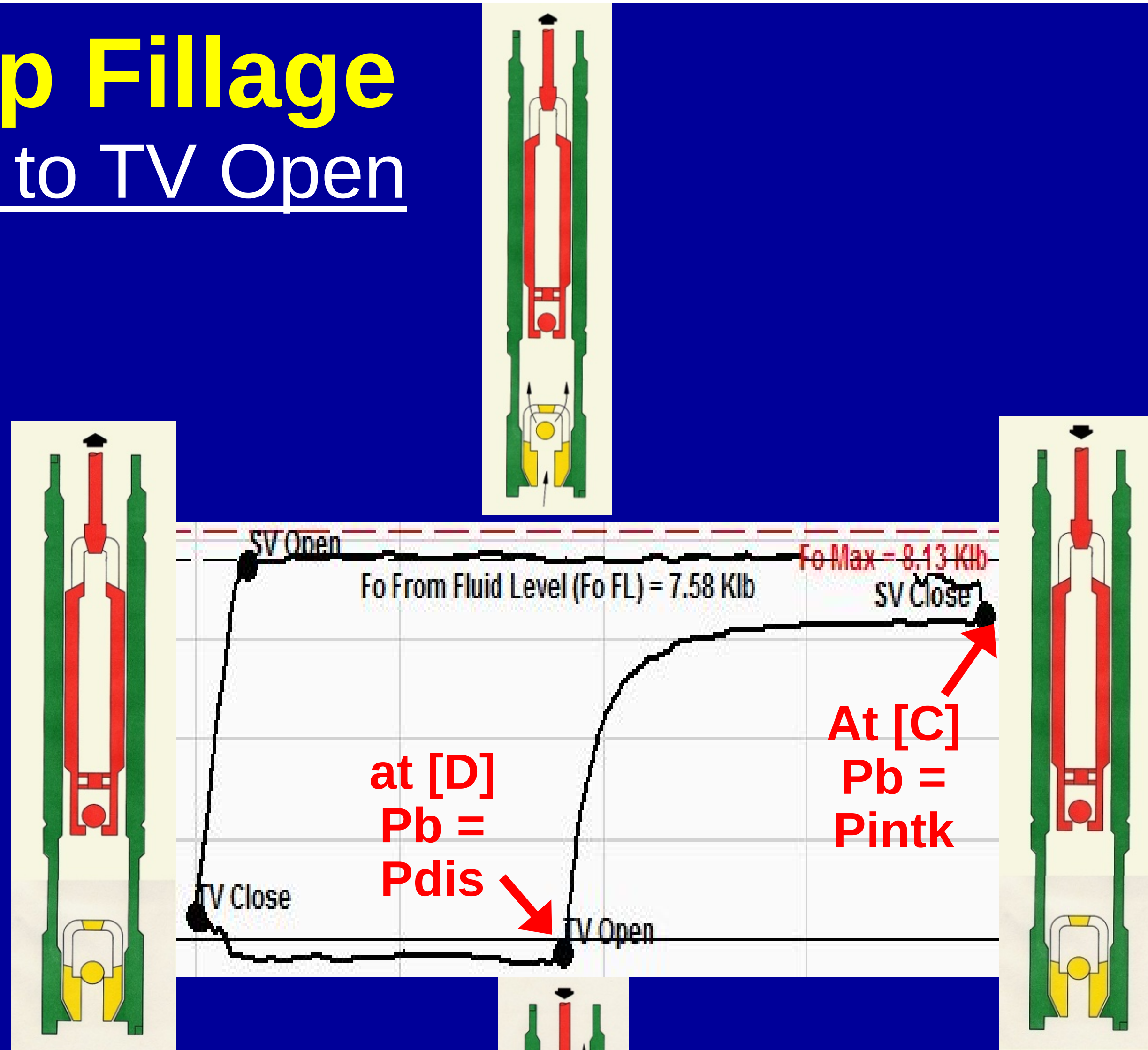
Incomplete Pump Fillage

Occurs from SV Close to TV Open

Steps from Top of Stroke to TV Open in Pump Operation

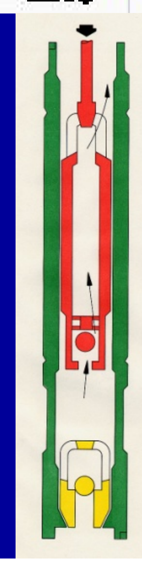
Pump acts as a Compressor

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



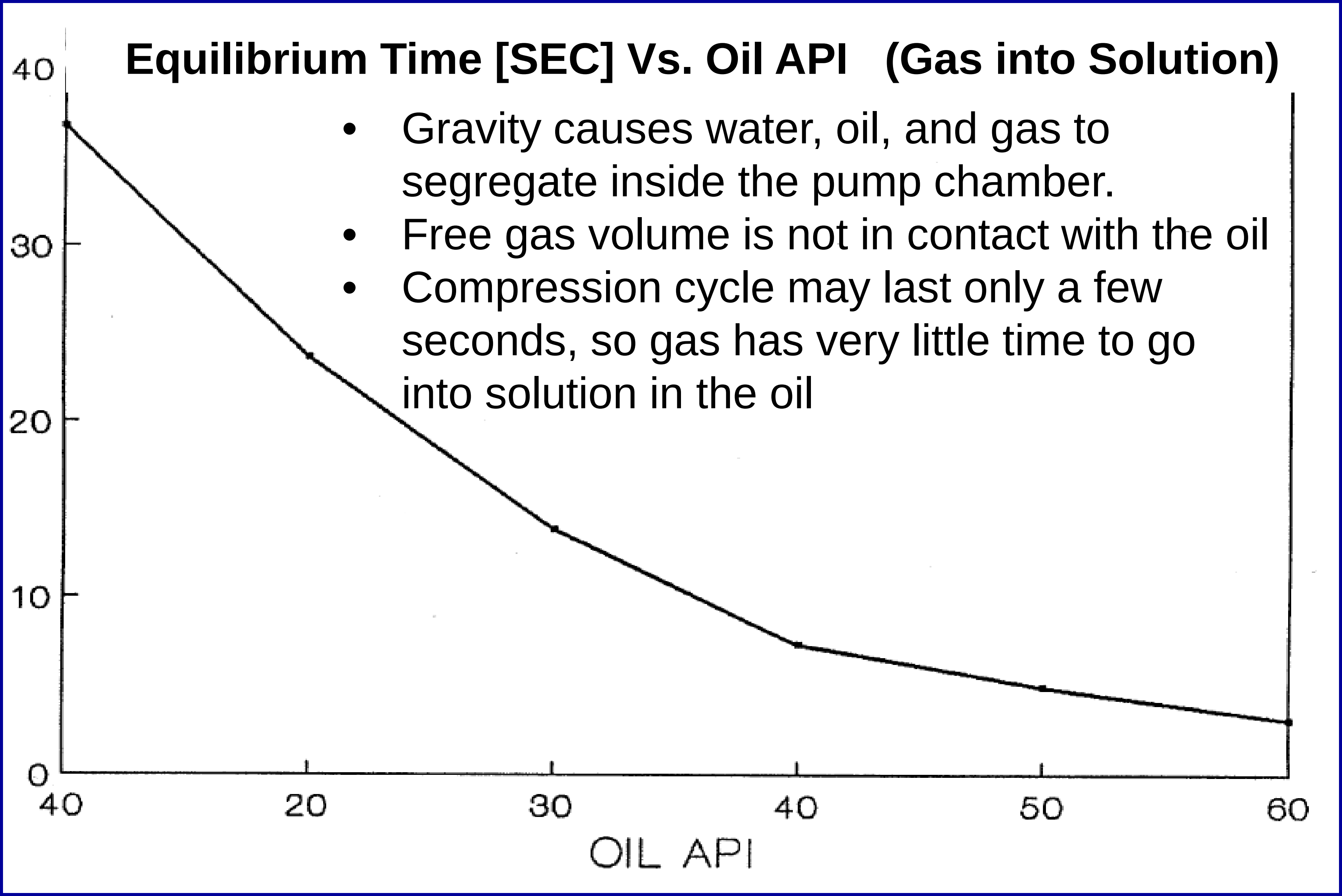
C) Standing Valve closes, when plunger reaches top of stroke, rods start to un-stretch to transfer fluid load, Fo, from rods [C] onto tubing [D].

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



C-D) Plunger applies pressure to fluids inside pump chamber, to compress fluids in Pump chamber and increase pressure.

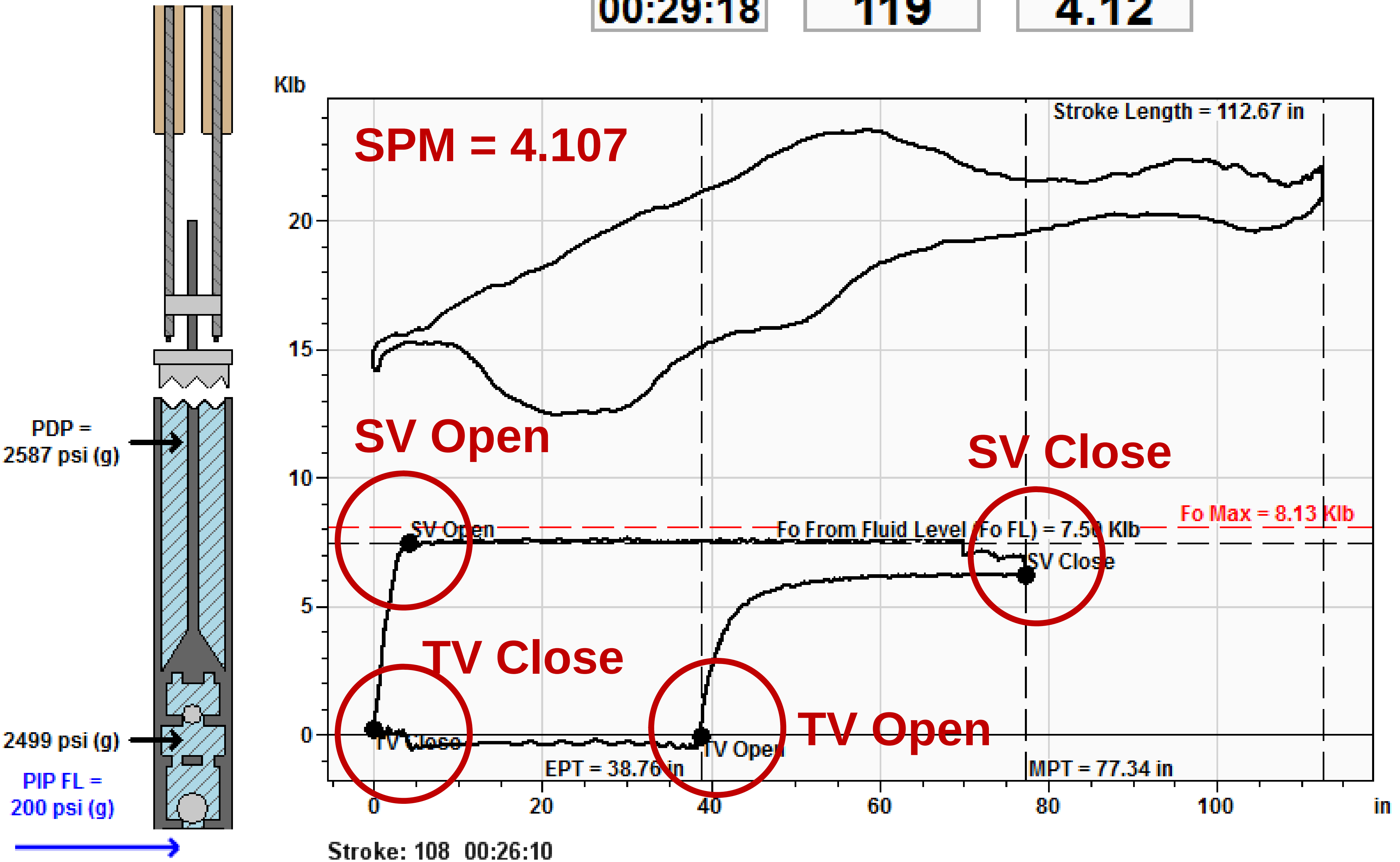
During gas compression process no free gas is assumed to go into solution



Hatem Tebourski, “Two-Phase Volumetric Efficiency in Sucker Rod Pumps”, The University of Tulsa Graduate School, 1995

Verify Valves Open and Close Correct

Test Duration	Total Strokes	Avg Test SPM
00:29:18	119	4.12



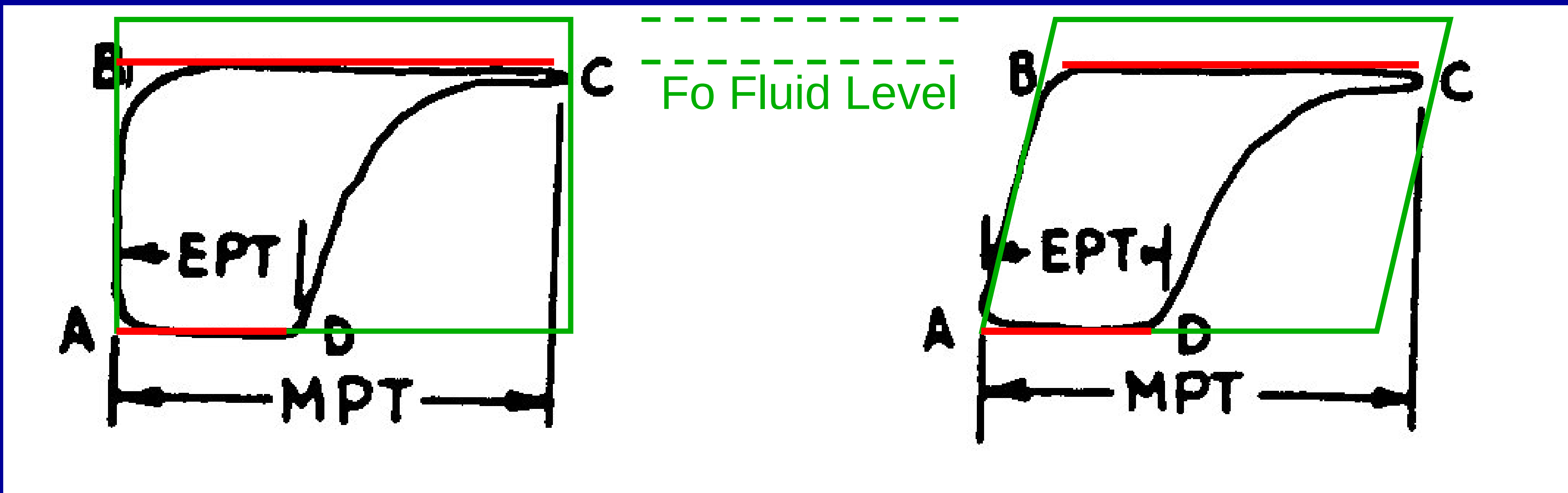
Stroke: 108 00:26:10

If Pumping and Card Load Line is Flat then Valve is Typically Open and Well Fluids Flowing thru Valve

Tubing anchored, EPT<MPT.

Fo Max

Unanchored tubing, EPT<MPT



Flat Pump card load line B-C, means that SV opens due to expansion of gas inside pump chamber when $P_{chamber} < P_{int}$

Flat Pump card load line D-A, means that TV opens due to compression of gas inside pump chamber when $P_{chamber} > P_{d}$

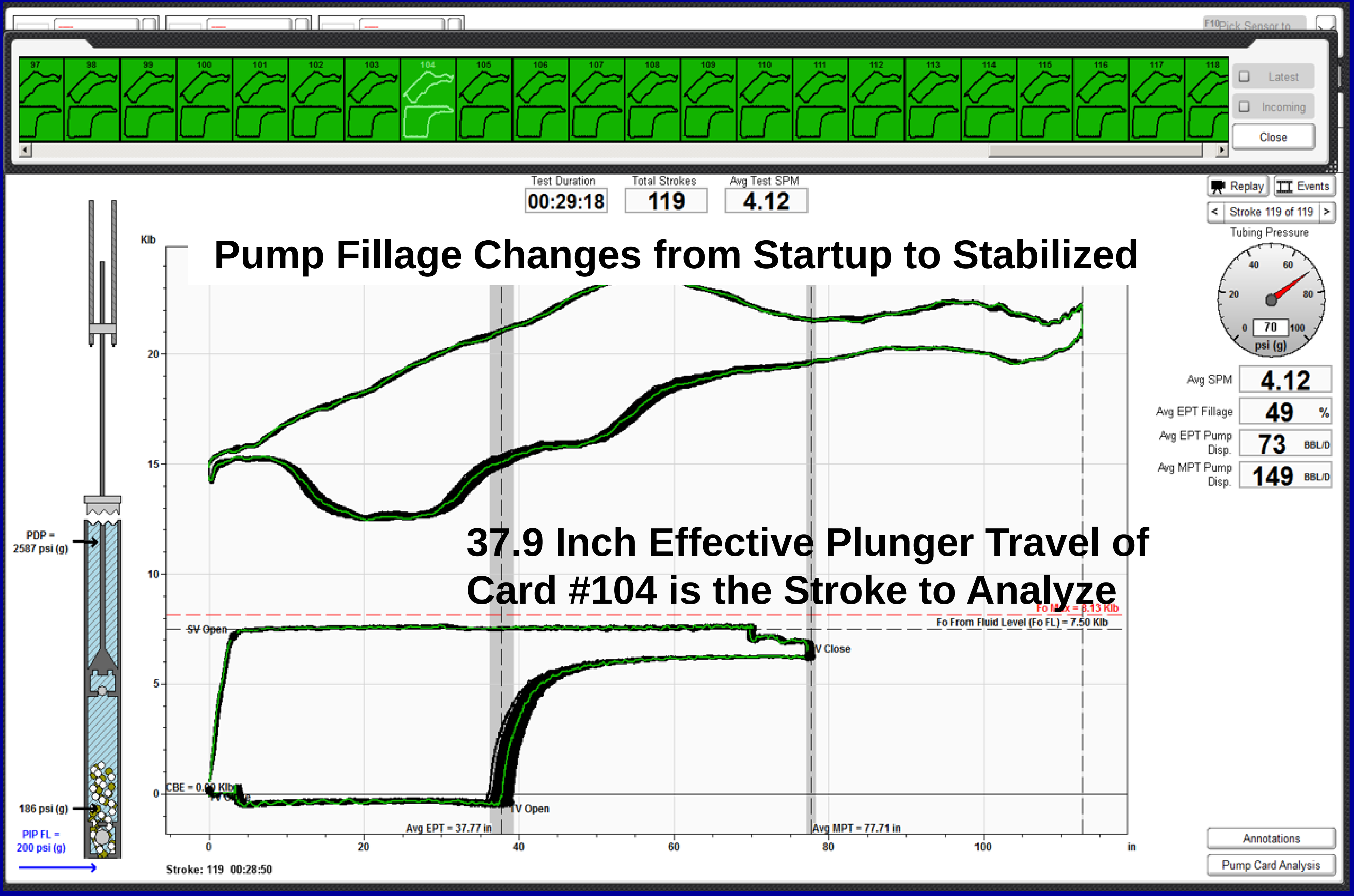
Determine the Tubing Fluid Gradient

- ○ Gas Free Gradient from Production — 0.365 psi/ft
  01/01/14 @ 59 BBL/D Oil and 0 BBL/D Water
- ○ Gradient from Measured Weight of Rods in Fluid — 0.365 psi/ft
  Standing Valve Test 01/09/2014 10:26:22AM
- ○ Multiphase Flow Gradient — 0.368 psi/ft
  Due to Liquid and Gas in Pump Flowing up Tubing
- ◉ User Entered — 0.320 psi/ft

☑ Include tubing back pressure from Polish Rod Piston Force — 124 lb

PDis = 0.32 x Pump Depth + Tubing Psig = 0.32x7865+70=2586.8

Select Representative Stroke to Analyze



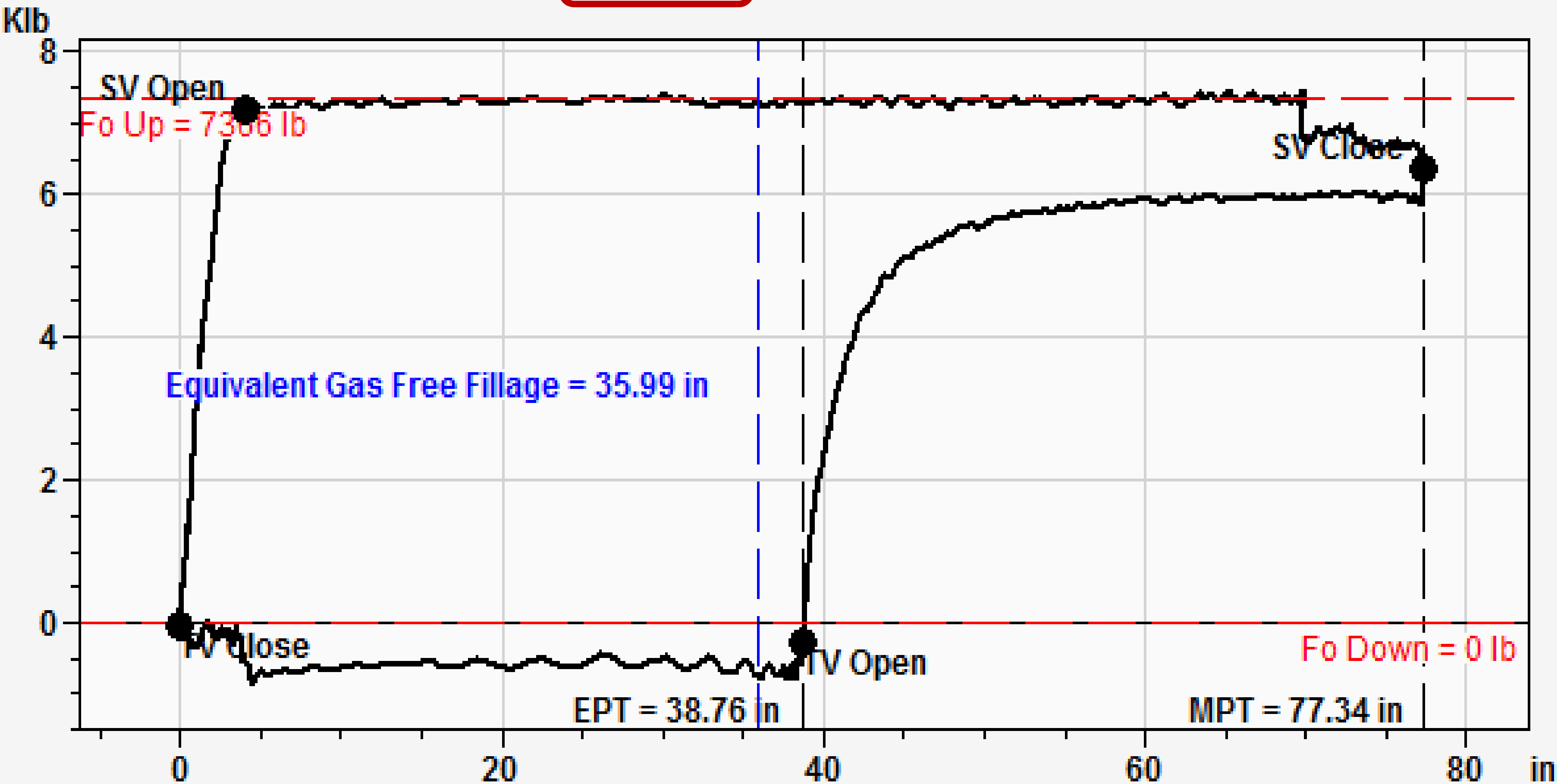
Determine PIP from Pump Card

Fo = FoUp - FoDown

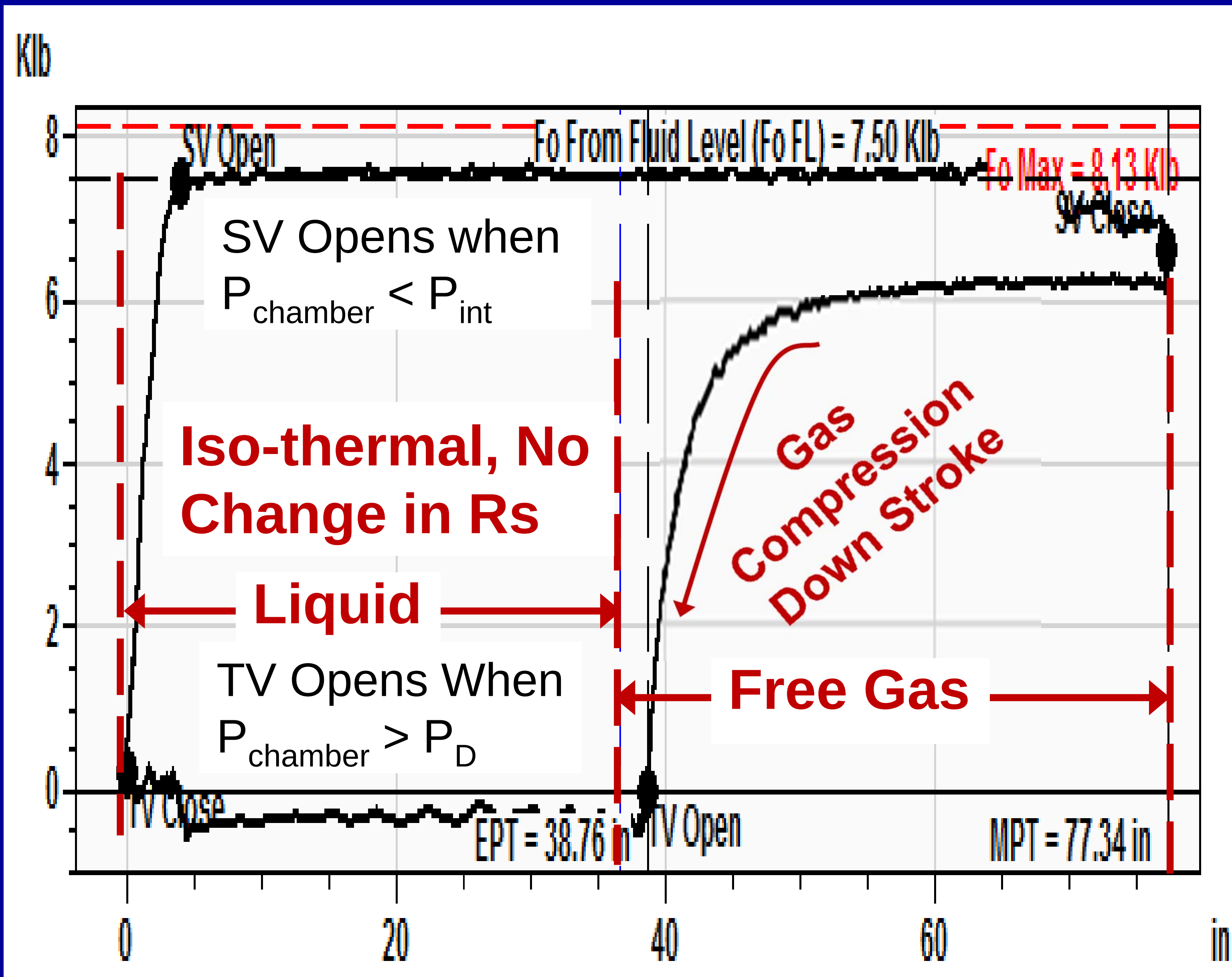
Fluid Load (Fo) 7366 lb

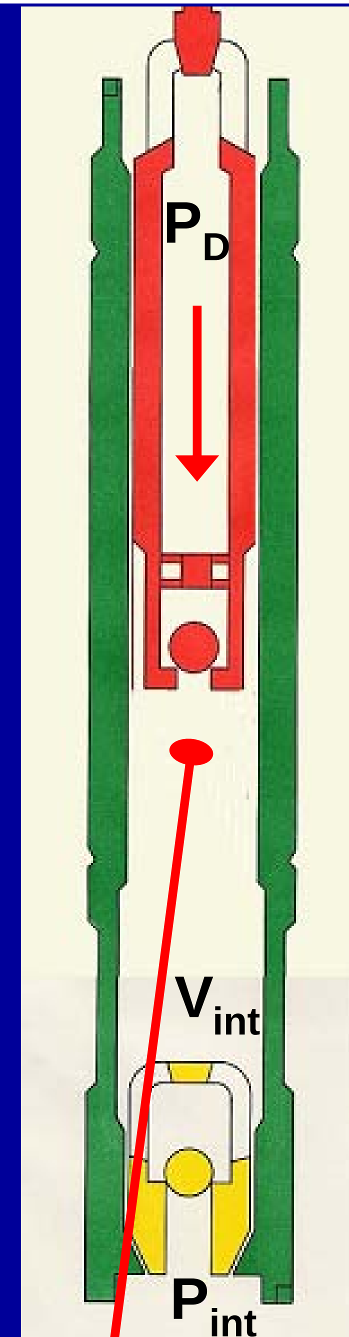
PIP = Tubing Pressure + Pump Depth(TVD) * Fluid Gradient - Fo/Plunger Area

Pump Intake Pressure 242.1 psi



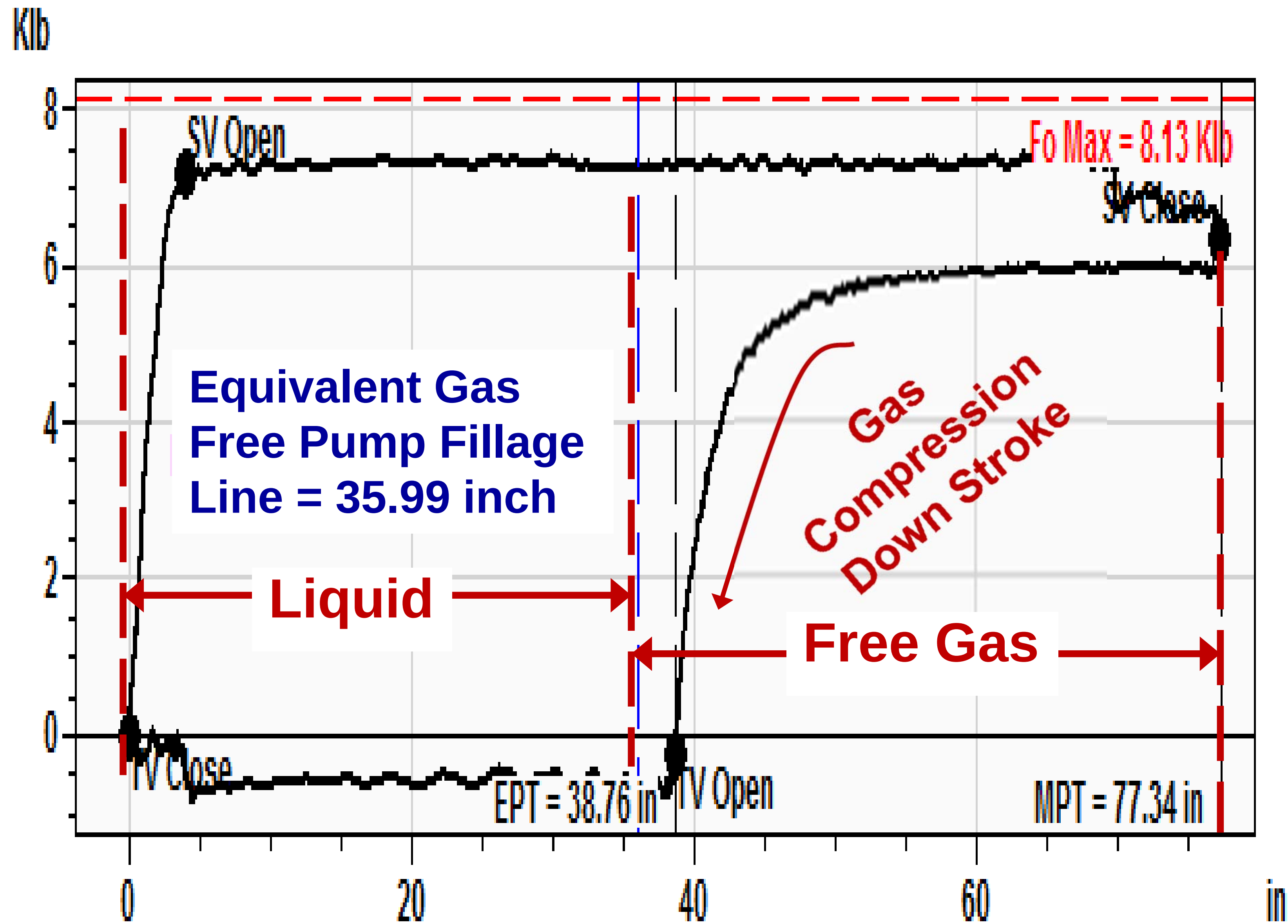
$$\text{Intake}\ \left(\frac{P_I V_I}{Z_I}\right) = \left(\frac{P_D V_D}{Z_D}\right)\ \text{Discharge}$$

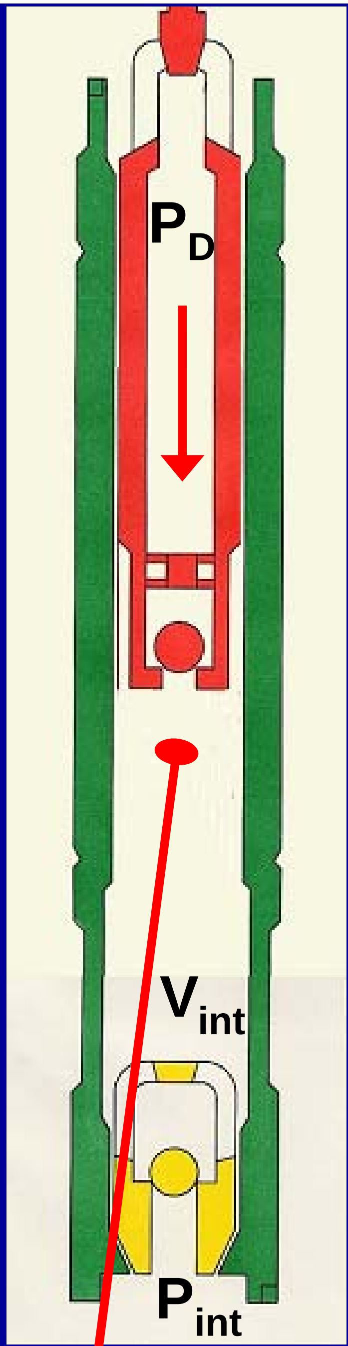




Compression Opens TV

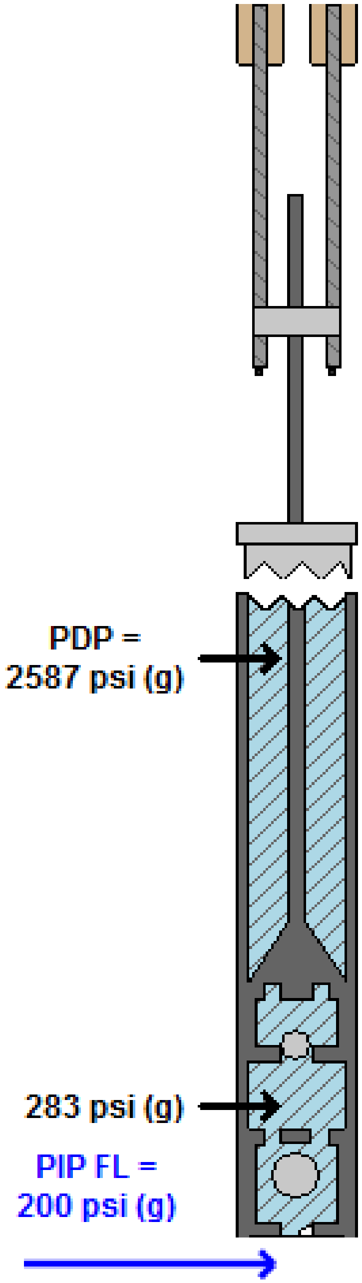
Gas Compression Curve Results From Compressing the Free Gas Volume Inside the Pump Chamber

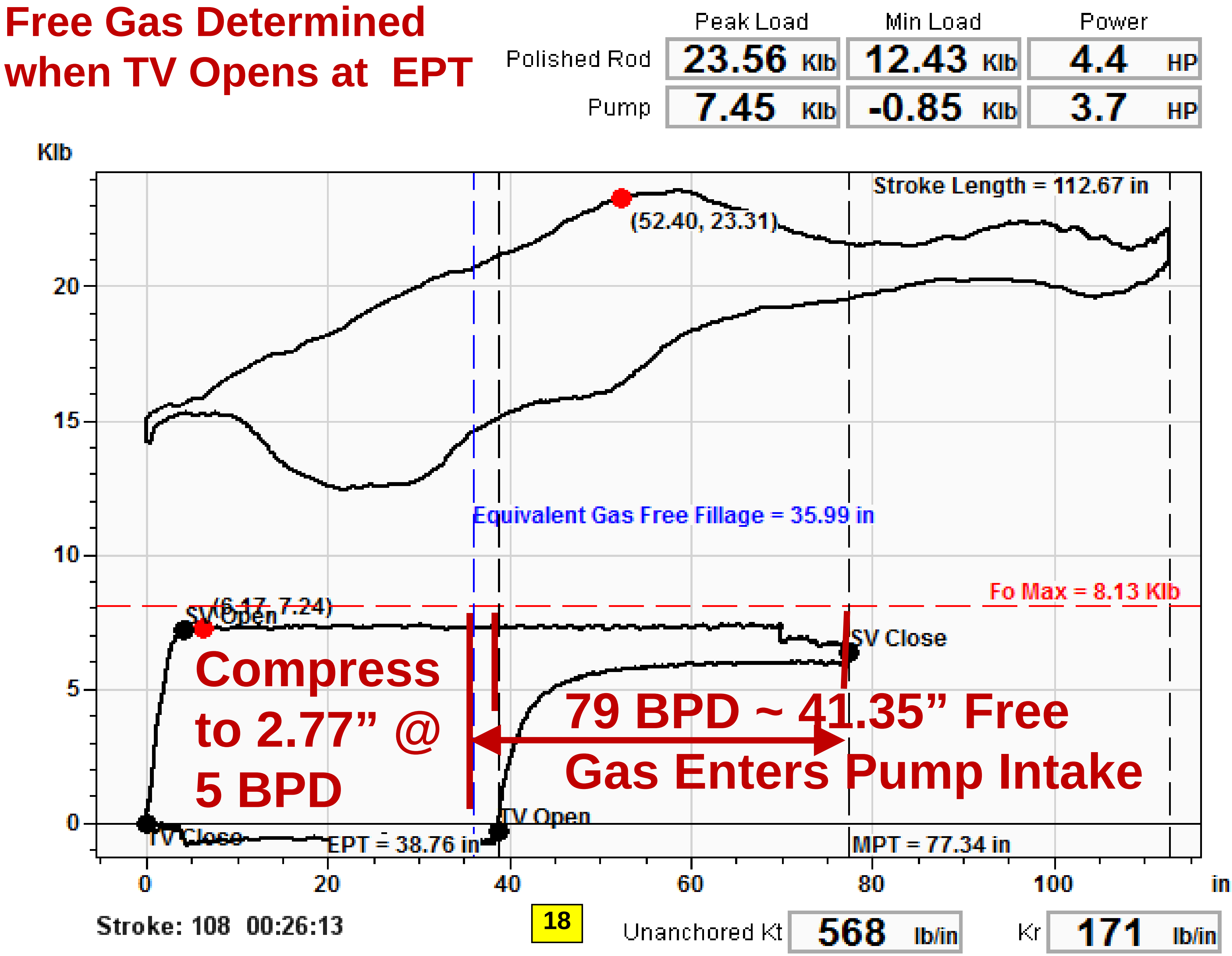




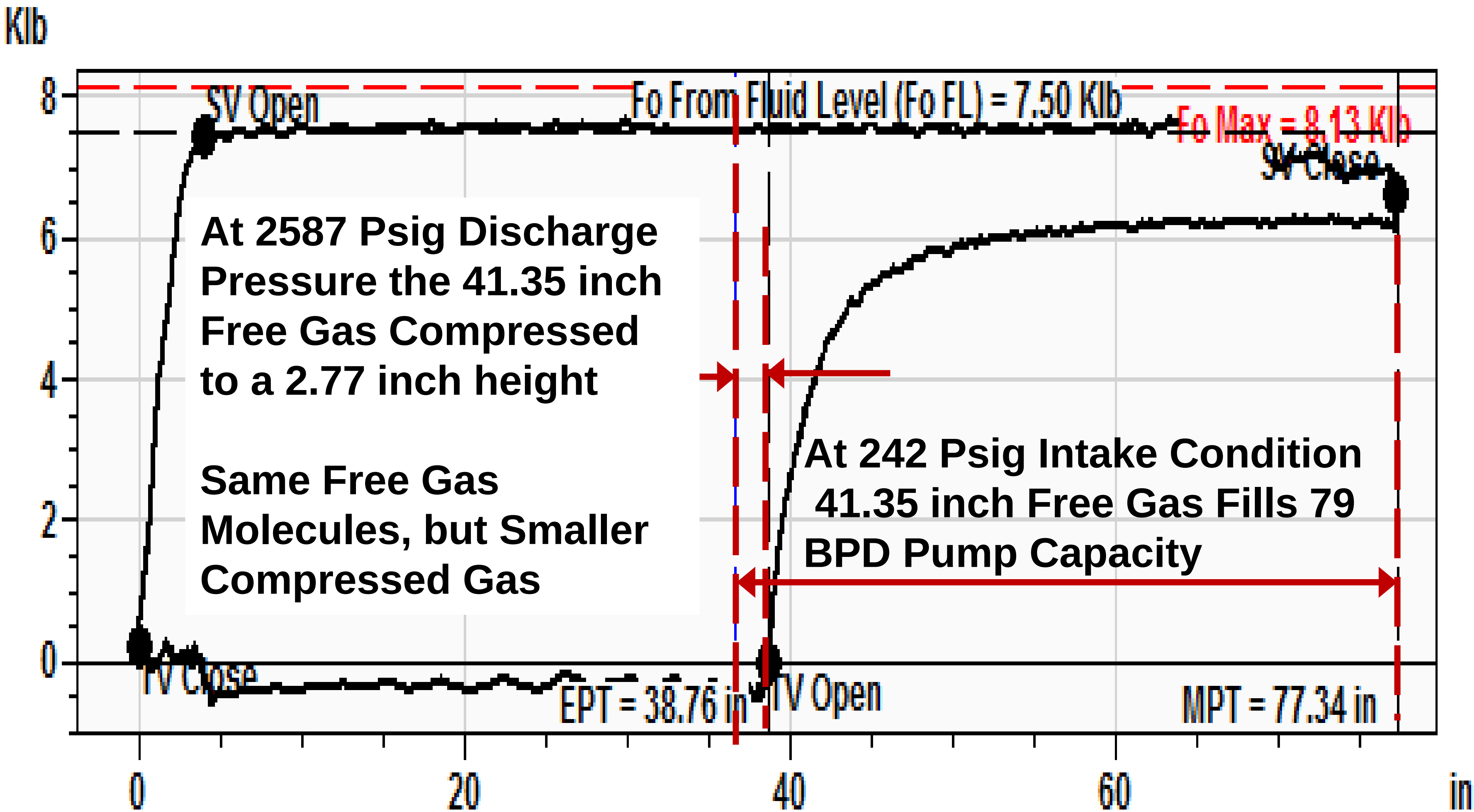
Compression Opens TV

Compress Gas Volume 15.8x From Intake 242 Psig to Discharge 2587 Psig Pressure





Using Fluid and Gas Properties at Both Intake and Discharge Condition, the Amount of Compressed Gas Filling the Pump Chamber Can Be Determined.



Patterson Pump Slippage Equation

modified ARCO-HF equation to include the effect of SPM on slippage

$$453 \cdot \left[\left(0.14 \cdot SPM \right) + 1 \right] \frac{DPC^{1.52}}{L\mu}$$

EXCEL Spreadsheet Available on USB:
"Pump Slippage Calculator_SPM_PattersonEq.xls"

- **D = nominal pump diameter, inches**
- **C = diametrical clearance, inches**
- **P = Pressure drop across the plunger, psi**
- **L = length of the plunger, inches**
- **SPM = strokes per minute**
- **μ = <u>viscosity of fluids, cp</u>**

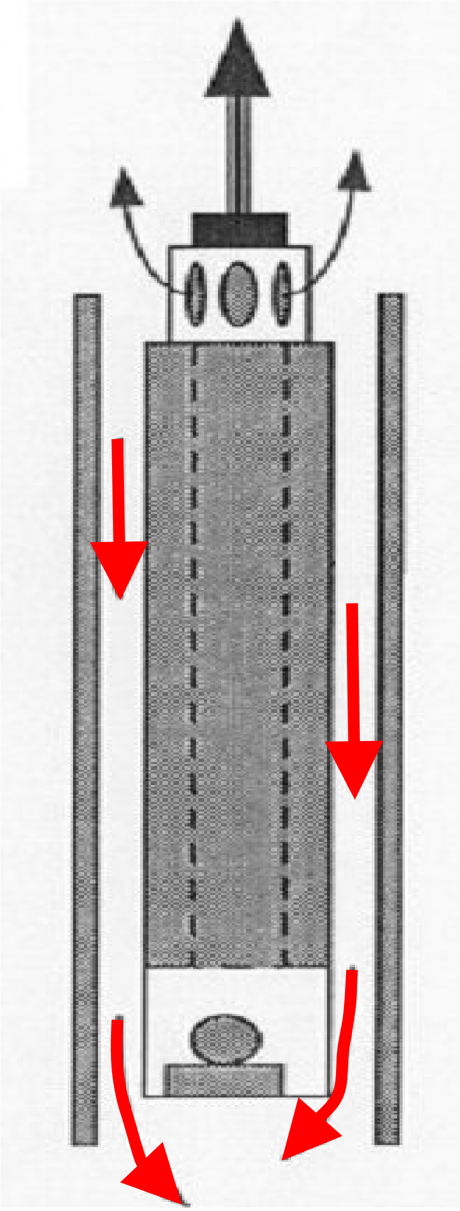
Patterson slippage equation estimates liquid slipping back into pump chamber

Slippage, BPD =

$$453 \cdot \left[\left(0.14 \cdot SPM\right) + 1\right] \frac{DPC^{1.52}}{L\mu}$$

1) Fluid that slips back into pump between the Plunger OD and the Barrel ID
2) Slips back into the pump chamber to reduces pump capacity
3) When traveling ball is on Seat.

BPD Tank = BPD Pump - Slippage



Presented at 2007 SWPSC

Progress Report #4 on "Fluid Slippage in Down-Hole Rod-Drawn Oil Well Pumps"

DO NOT DO THIS

John Patterson – ConocoPhillips Company
Kyle Chambliss - Oxy Permian
Lynn Rowlan – Echometer
Jim Curfew – Oxy Permian

Based on Slippage test, "the following minimum pump clearances are recommended for a 48" Plunger with a "+1 Barrel". These clearances have become widely used in the Permian Basin for well depths up to 8000 feet"

- 1.25" pump = -3 to -4 plunger (0.004" to 0.005" total clearance)
- 1.50" pump = -4 to -5 plunger (0.005" to 0.006" total clearance)
- 1.75" pump = -5 to -6 plunger (0.006" to 0.007" total clearance)
- 2.00" pump = -6 to -7 plunger (0.007" to 0.008" total clearance)

Rule-of-Thumb Table

???? Design: Clearance Using Patterson Eq. w/ 90% Pump Efficiency

Inputs to Pump Slippage Calculations

D=Plunger Diameter (inches)	1.5
*P=Pressure Differential	3617
C=Clearance (inches)	0.006
u=Fluid Viscosity (centipoise)	0.76
Plunger length (inches)	48
Strokes per Minute	8

***Calculating Differential Pressure**

Pump Depth	8000
Tubing Discharge Pressure (Psi)	250
Tubing Fluid Gradient (Psi/Ft)	0.4271
Pump Intake Pressure (Psi)	50
Input your production rate, BPD	274.0
Slippage in BPD	59.9

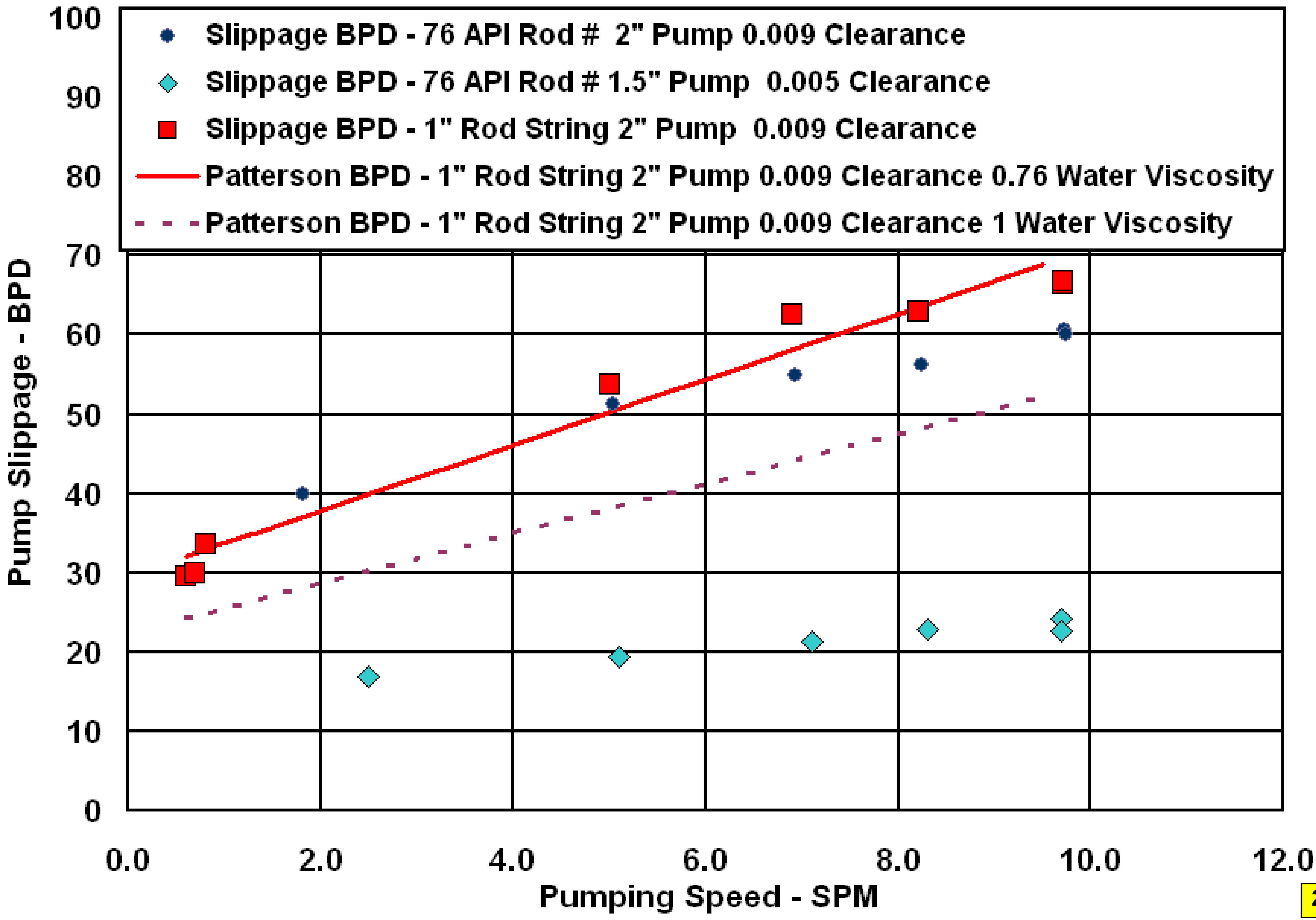
Use Slippage Equation

If You Use Recommended Clearances from 2007 ~~Rule-of-Thumb Table~~

Plunger Size Inch	Total Clearance Inch	Slipage BPD	100" Stroke Pump Disp. BPD	Slippage %	144" Stroke Pump Disp. BPD	Slippage %
1.25	0.005	37.8	131	28.9	208	18.2
1.50	0.006	59.9	143	41.9	274	21.9
1.75	0.007	88.4	172	51.4	324	27.3
2.00	0.008	123.7	200	61.9	349	35.4
2.25	0.009	166.5	211	78.9	401	41.5

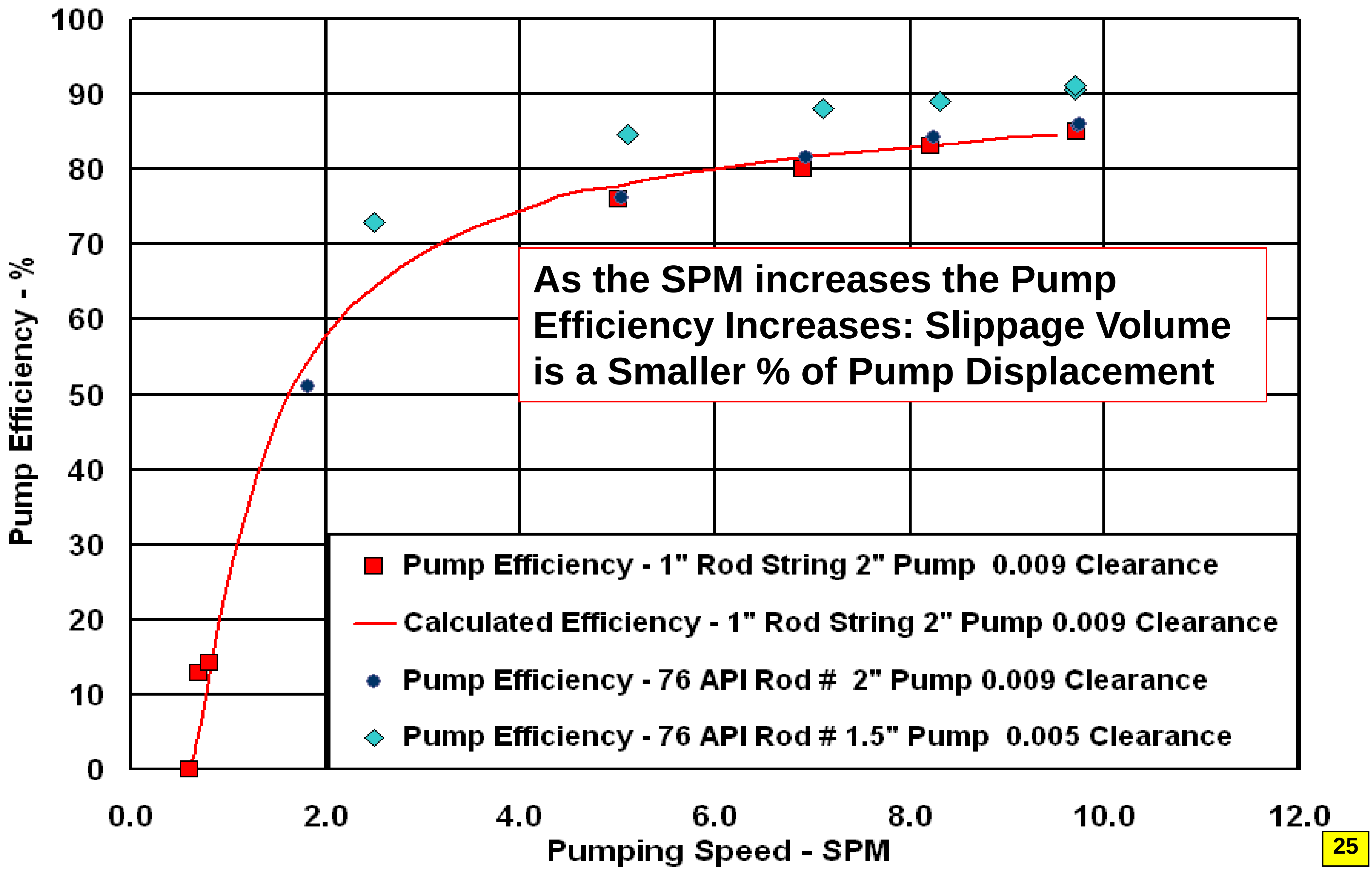
86 API Rod String | Anchored Tubing | Red - D Rod Loading > 100%

μ - Viscosity is used in Slippage Calculation

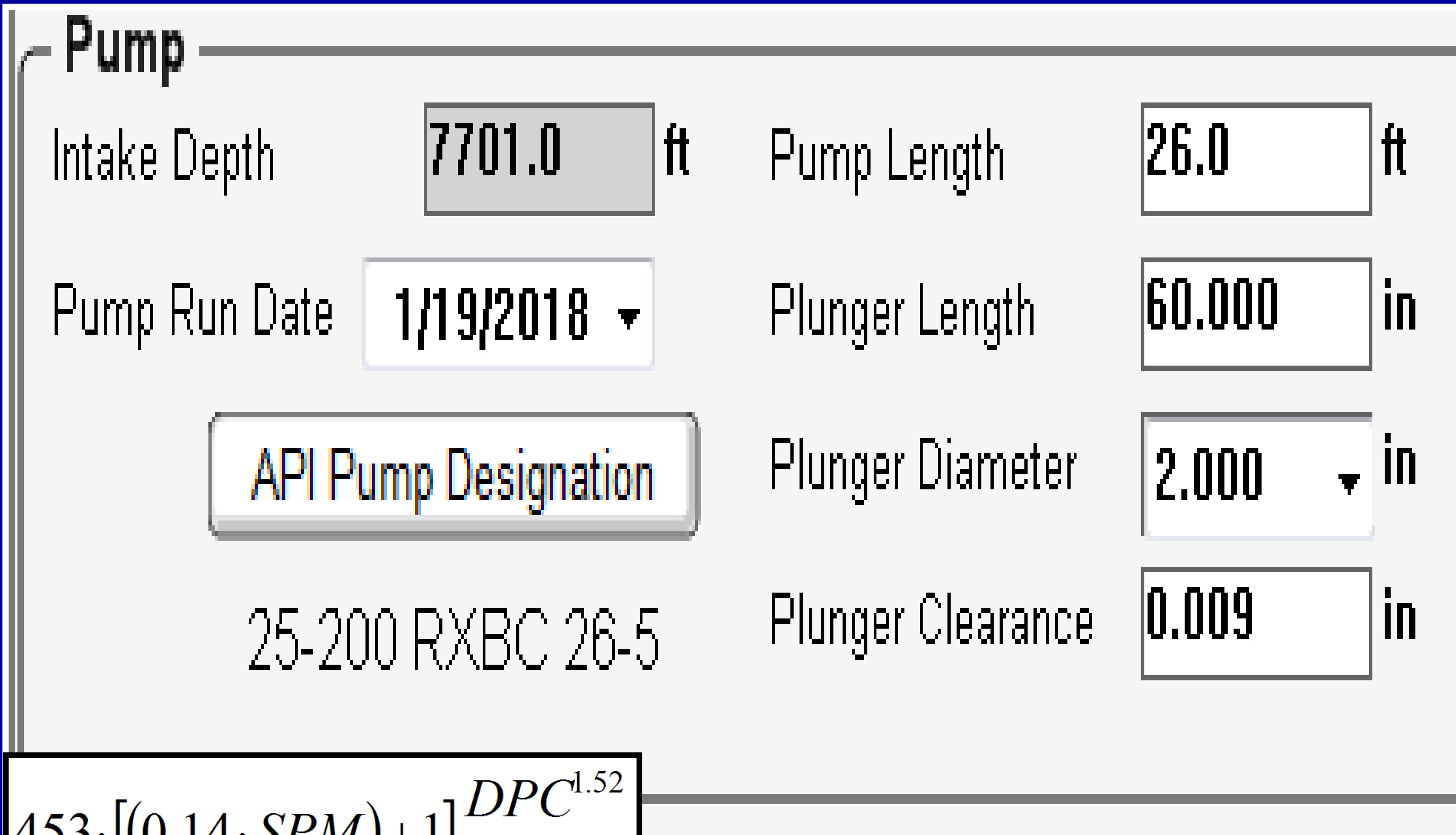


Pump Speed vs Pump Efficiency

$$PumpEfficiency\% = \frac{SurfaceRate}{PumpDisplacment} \times 100$$



Plunger Length, Diameter, Clearance Input Important



$$453 \cdot [(0.14 \cdot SPM)+1] \frac{DPC^{1.52}}{L\mu}$$

Viscosity f(P, T, Pb, Oil Wat Gas SG)

What about a mixture viscosity based on %Oil and % Water?

Pressure (psia)	R_s (SCF/BO)	B_o (vol/vol)	μ_o (cp)	z_g	B_g (vol/vol)	μ_g (cp)	B_w (vol/vol)	μ_w (cp)	c_w (1/psi)
100	10.3	1.0815	4.440	0.991	0.19049	0.0133	1.0459	0.274	9.07E-07
500	57.8	1.1011	3.610	0.957	0.03678	0.0138	1.0455	0.279	1.08E-06
350	38.5	1.0931	3.906	0.969	0.05323	0.0136	1.0457	0.277	1.04E-06
600	71.3	1.1067	3.427	0.949	0.03040	0.0140	1.0454	0.280	1.17E-06
850	106.9	1.1218	3.024	0.930	0.02104	0.0145	1.0451	0.283	1.30E-06
1100	144.7	1.1381	2.690	0.914	0.01597	0.0150	1.0448	0.286	1.44E-06
1350	184.2	1.1555	2.412	0.900	0.01282	0.0157	1.0444	0.289	1.57E-06
1600	225.3	1.1738	2.180	0.890	0.01069	0.0165	1.0440	0.293	1.70E-06
1850	267.7	1.1930	1.984	0.882	0.00917	0.0173	1.0435	0.296	1.83E-06
2100	311.2	1.2131	1.818	0.878	0.00804	0.0182	1.0430	0.300	1.96E-06
2326	351.5	1.2319	1.688	0.877	0.00725	0.0191	1.0426	0.303	2.10E-06
2626	351.5	1.2300	1.736	0.880	0.00644	0.0203	1.0419	0.308	2.26E-06
2926	351.5	1.2282	1.791	0.886	0.00582	0.0215	1.0412	0.312	2.42E-06
3226	351.5	1.2263	1.852	0.896	0.00534	[illegible]	[illegible]	[illegible]	[illegible]
3626	351.5	1.2239	1.941	0.914	0.00485	0.0246	1.0394	0.324	[illegible]

PIP 843

P Avg 2187

PDP 3532

EXCEL Spreadsheet Available on Ask (((ECHOMETER)))

Use Oil Only Viscosity at Average of PDP to PIP at Pump Temp at Oil Pb

Production

Oil	Water	Total Fluid	Oil Cut	Water Cut
13.5	433	446.5	0.0302	0.9698

PIP Psia	Oil	Water	Total Fluid
	<============ Viscosity ===========>		
843	3.16279 ?	0.28311 ?	0.37018 ?

Discharge Psia	Oil	Water	Total Fluid
	<============ Viscosity ===========>		
3532	1.91612 ?	0.32094 ?	0.36917 ?
Average	2.53945207		0.36967549 ?

Note: Use Oil Viscosity when oil gravity is less than 30-32 Degree API
Use Total Fluid when oil gravity is greater than 30-32 Degree API
Use 0.76 cp water only oil gravity is greater than 30-32 Degree API

EXCEL Spreadsheet Available on Ask (((ECHOMETER)))

Measured Rate Matches Calculated

Pump

	in	BBL/D
Maximum Plunger Travel	165.33	
Free Gas in Pump at Intake	1.32	4
Effective Plunger Stroke	164.21	475
Free Gas in Pump at Discharge	0.20	1
TV Close Delay	0.00	0
Slippage (Patterson)	8.02	23
Pump Displacement	155.99	451

- ☑ Adjust Free Gas in Pump at Intake for Tubing Stretch
  - ◉ Kt Anchored
  - ○ Kt Unanchored
- ☑ Adjust Pump Displacement for Gas in Pump
- ☑ Adjust Pump Displacement for TV NOT closing at bottom of stroke
- ☑ Adjust Pump Displacement for Slippage
- ☑ Adjust Pump Displaced Liquid to Surface Stock Tank Conditions

Liquid

Viscosity of Fluids μ=2.539 cp

	Pump Discharge BBL/D	(Calc) Surface Stock Tank BBL/D	(Input) Surface Stock Tank BBL/D
Oil	14	12	14
Water	438	432	433
Total Liquid	451	445	447

Determine Fluid Viscosity for Slippage Eq.

Use Default 0.76 cp water viscosity for a "good" guess.

- **Use Oil Only Viscosity when oil gravity is less than 30-32 Degree API**
- **Use Total Fluid (based on %Oil and %Water) when oil gravity is greater than 30-32 Degree API**
- **For Pressure use Average of (PIP + PDP)**
- **Use Temperature at Pump Depth**
- **Must Know Plunger Length, Diameter, Clearance**
- **Should Know Oil, Water, and Gas Gravities**
- **Set Bubble Point Pressure equal to Pump Intake Pressure to determine Gas in Solution going into the pump.**

SlippageViscosityCalculator.xls Available on Ask (((ECHOMETER)))

$$Slippage = [(0.14 \cdot SPM) + 1]453 \frac{DPC^{1.52}}{L\mu}$$

Patterson Slippage

Inputs to Pump Slippage Calculations

D=Plunger Diameter (inches)	2
*P=Pressure Differential	2412
C=Clearance (inches)	0.003
u=Fluid Viscosity (centipoise)	0.76
Plunger length (inches)	60
Strokes per Minute	4.12

*Calculating Differential Pressure

Pump Depth	7865
Tubing Discharge Pressure (Psi)	70
Tubing Fluid Gradient (Psi/Ft)	0.32
Pump Intake Pressure (Psi)	242
Slippage in BPD	**11.1**

11 BPD of Slippage

Results in 5.6 Inches of Reduced Pump Capacity

Input Data: Clearances, Plunger Length, Fluid Viscosity

EXCEL Spreadsheet Available on USB: "Pump Slippage Calculator_SPM_PattersonEq.xls"

Effective Plunger Travel – Free Gas in Pump – Slippage = ***<u>Pump Displacement</u>***

Pump

		in	BBL/D
	Maximum Plunger Travel	77.34	
=	Free Gas in Pump at Intake	41.35	79
+	Effective Plunger Stroke	38.76	74
-	Free Gas in Pump at Discharge	2.77	5
	TV Close Delay	0.00	0
-	Slippage (Patterson)	5.60	11
=	Pump Displacement	30.39	58

Adjust Liquid Volumes for Gas in Solution and P & T Change from Pump to Surface

Liquid

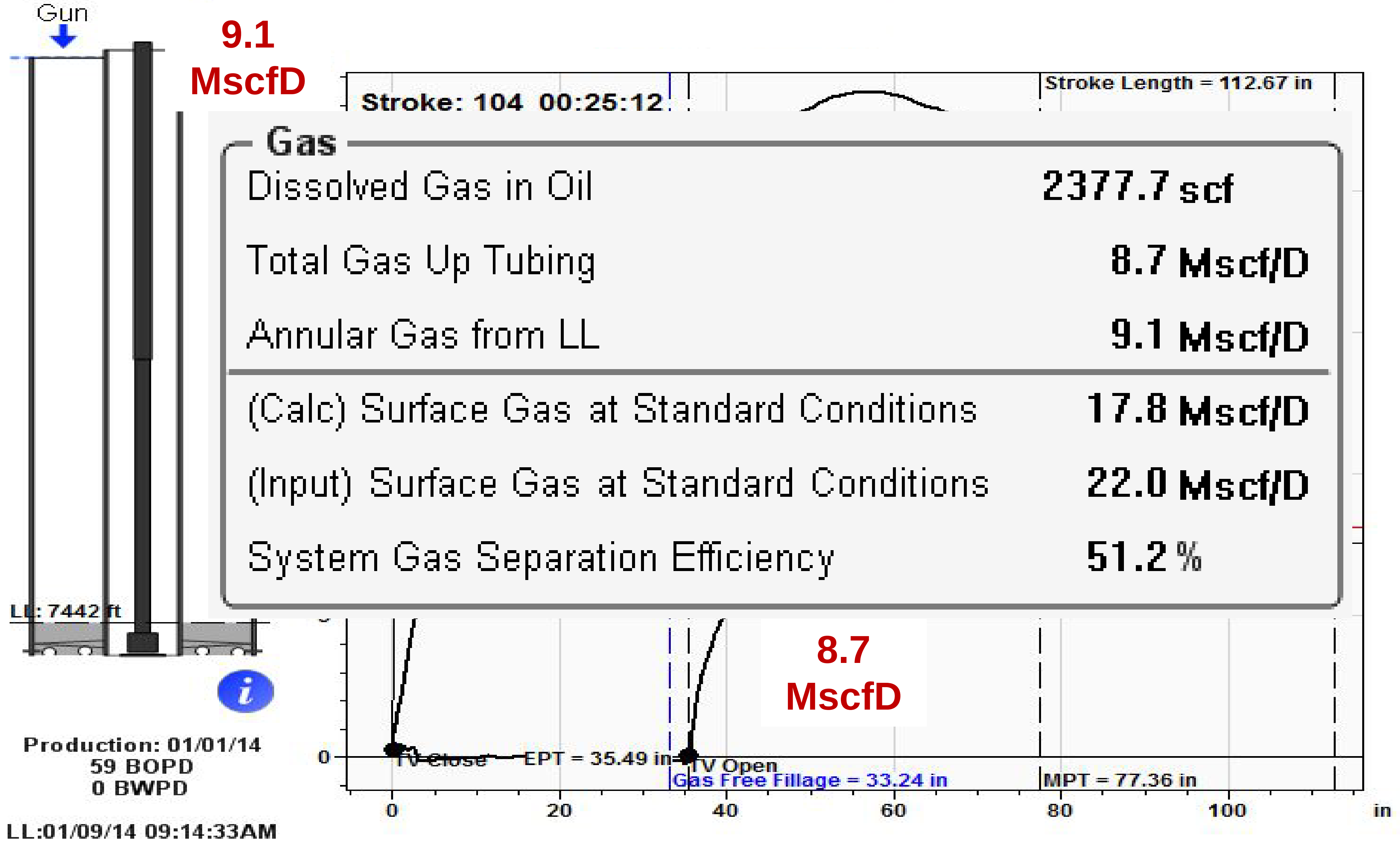
	Pump Discharge	(Calc) Surface Stock Tank	(Input) Surface Stock Tank
	BBL/D	BBL/D	BBL/D
Oil	58	53	59
Water	0	0	0
Total Liquid	58	53	59

Standing Fluid Property Correlations used to Determine Gas in Solution at Intake Pressure and Volume Change due to Temperature and Pressure

Gas Volumes 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



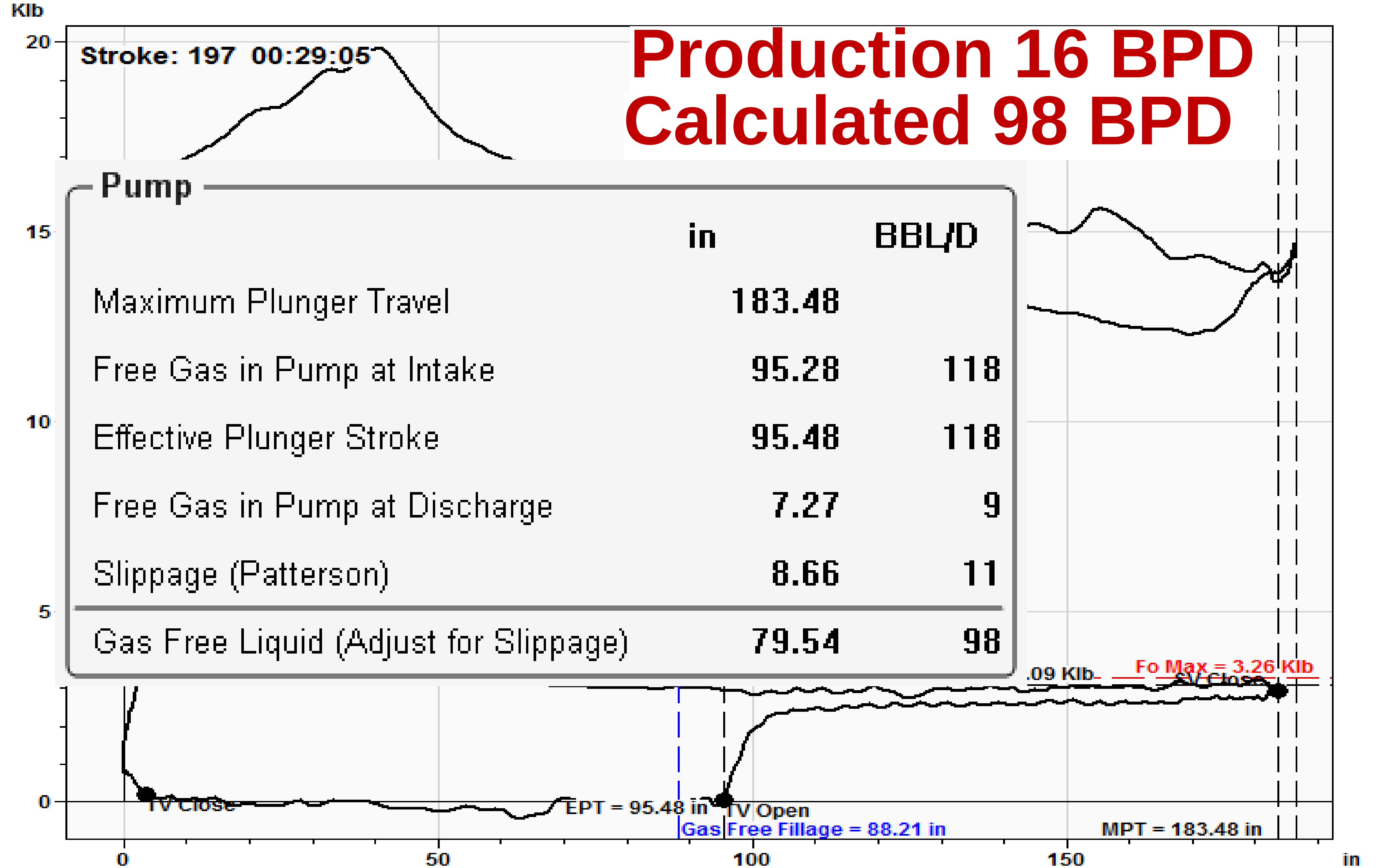
Gas

Dissolved Gas in Oil	2377.7 scf
Total Gas Up Tubing	8.7 Mscf/D
Annular Gas from LL	9.1 Mscf/D
(Calc) Surface Gas at Standard Conditions	17.8 Mscf/D
(Input) Surface Gas at Standard Conditions	22.0 Mscf/D
System Gas Separation Efficiency	51.2 %

Enhanced Analysis Technique Determines "Equivalent Gas Free Pump Fillage" Line

- "Equivalent Gas Free Pump Fillage" Line Represents the Amount Of Liquid Fillage In the Pump When the Traveling Valve Opens During the Down Stroke.
- Enhanced Analysis Technique Allows Answering Many Of the Complicated Questions Concerning Oil, Water And Gas Production With Respect To the Maximum Plunger Travel, MPT, and Effective Plunger Travel, EPT.

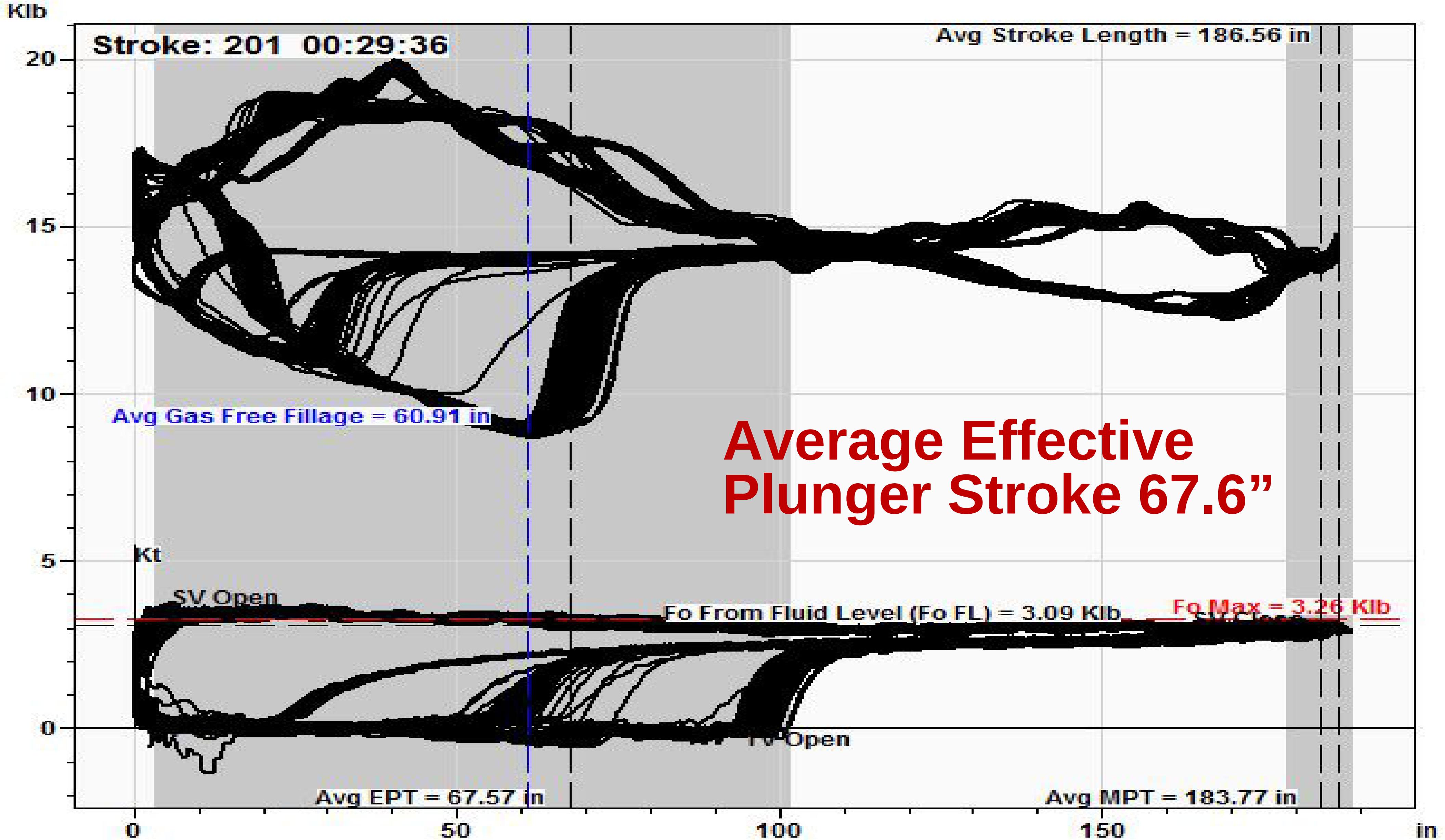
Select Representative Stroke 197?



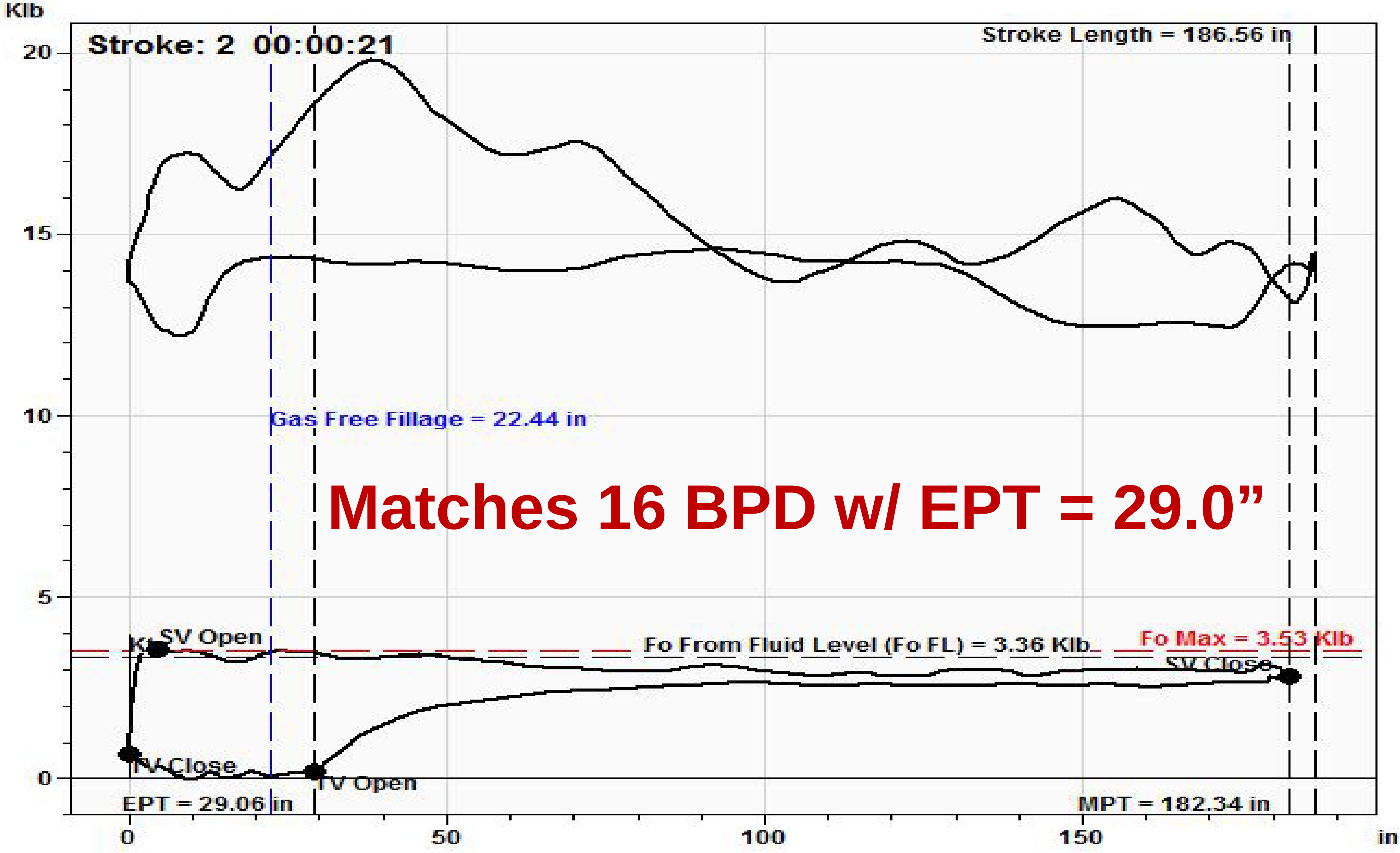
Pump

	in	BBL/D
Maximum Plunger Travel	183.48	
Free Gas in Pump at Intake	95.28	118
Effective Plunger Stroke	95.48	118
Free Gas in Pump at Discharge	7.27	9
Slippage (Patterson)	8.66	11
Gas Free Liquid (Adjust for Slippage)	79.54	98

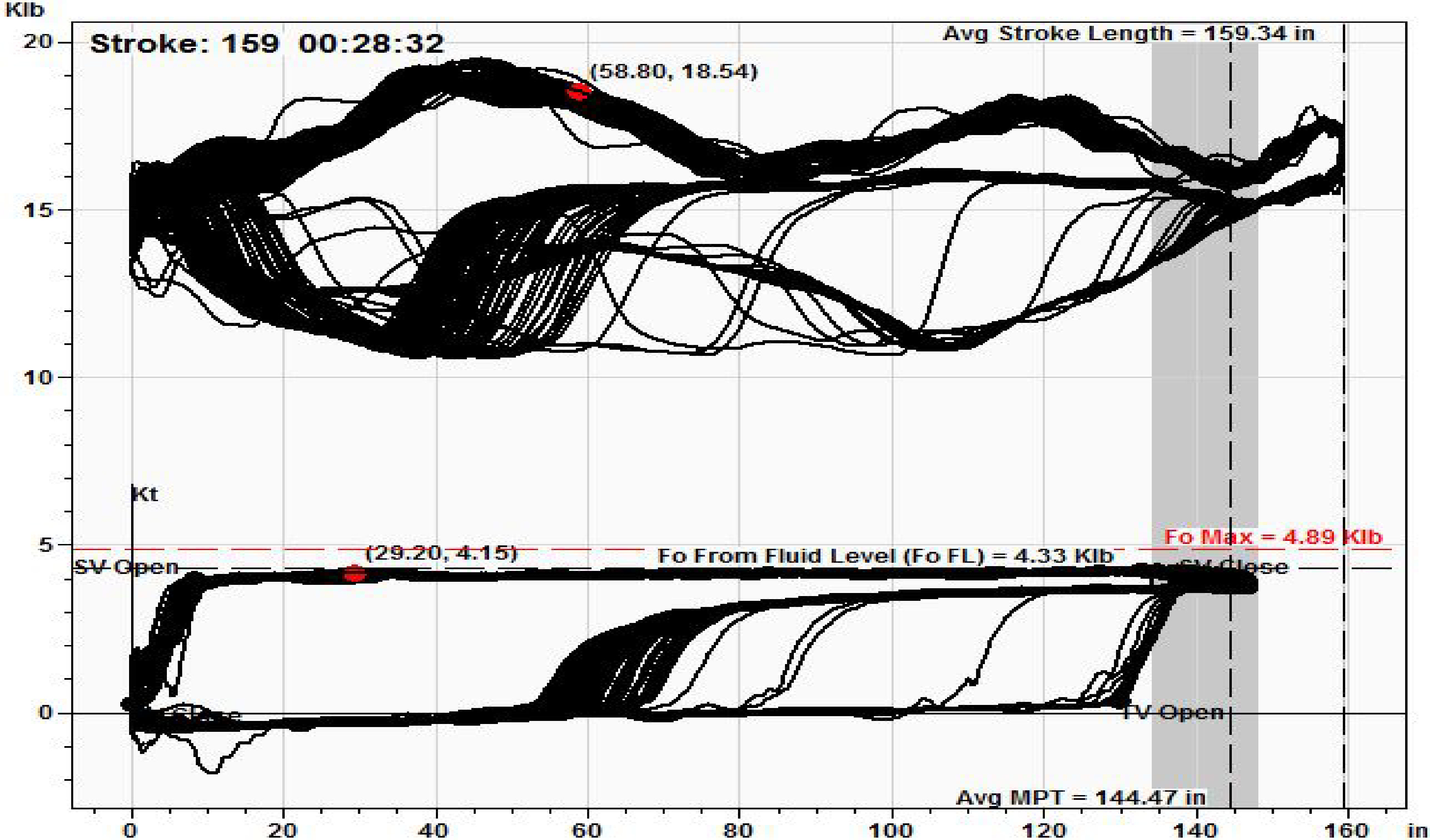
Notice How Pump Fillage Changes



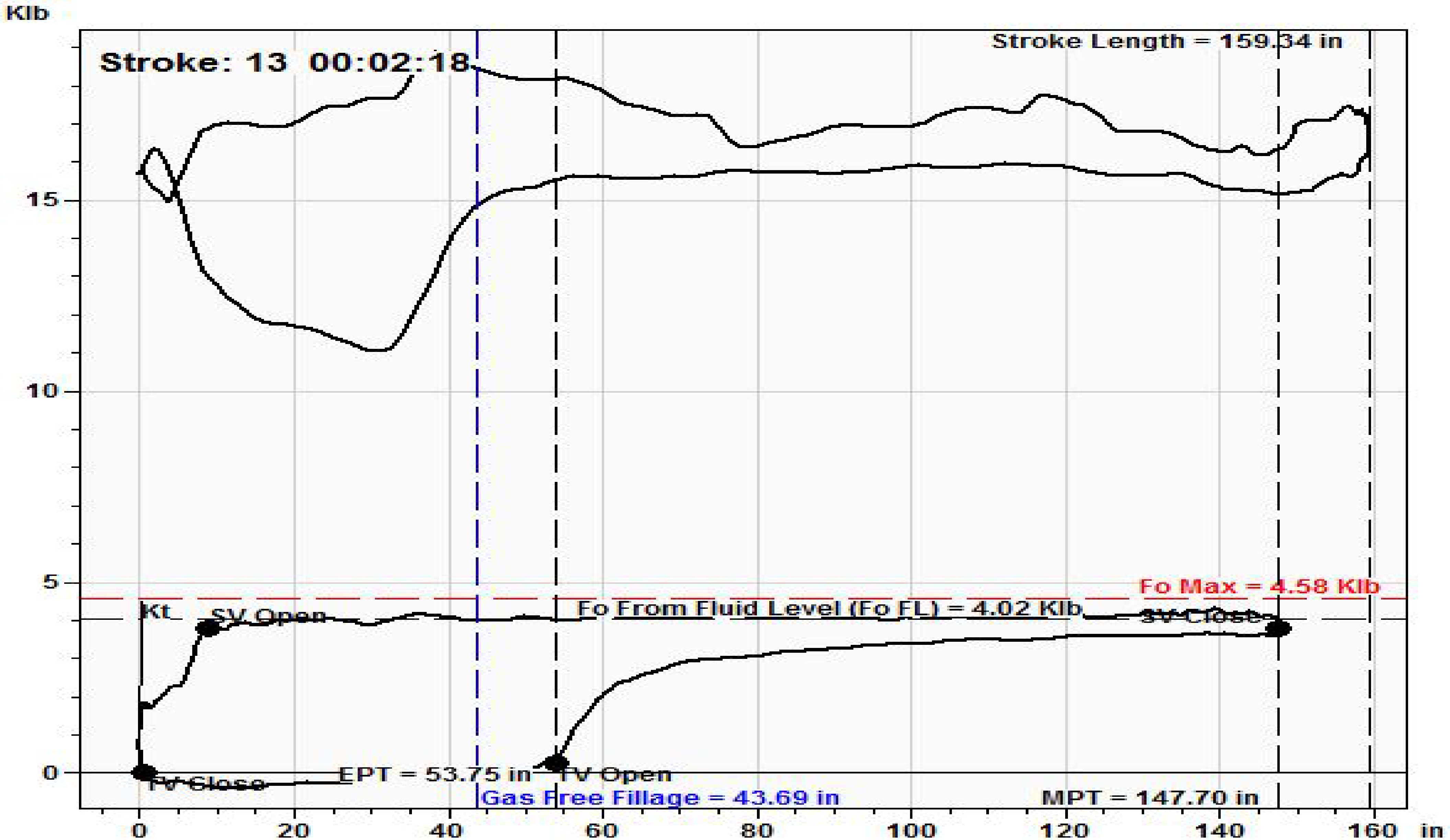
To Match Reported Production Rate Must Select Stroke with 29” EPT



Representative Stroke 53.75 EPT?

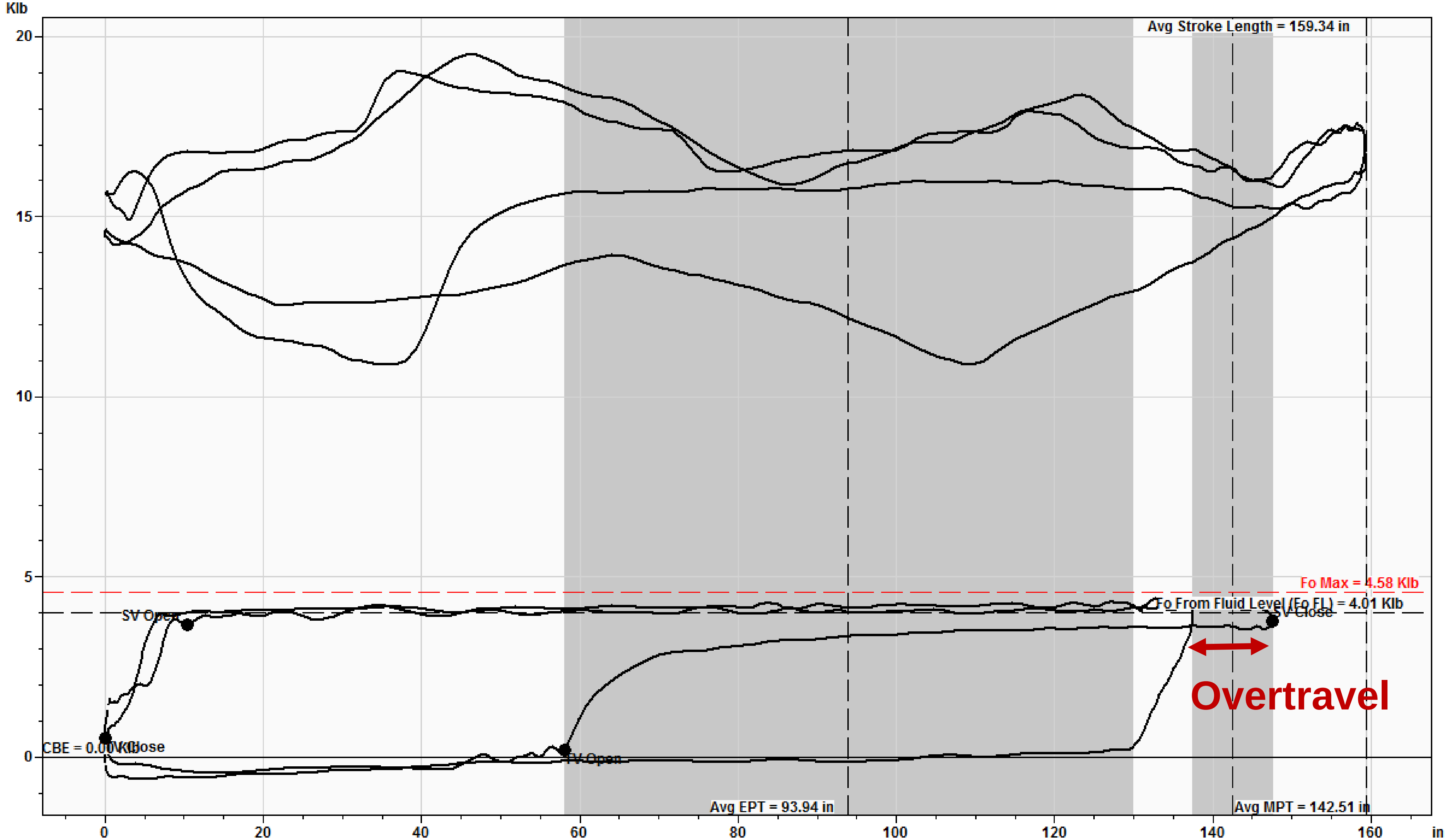


56 BPD Calculated vs 20 BPD Measured



Echometer Online_LiquidPumpPumps: RunTime

Low Pump Fillage Causes Overtravel on Downhole Stroke Length



12 Hour Run Time Must be Considered in Production Rate Calculations

24 Hour Run Time

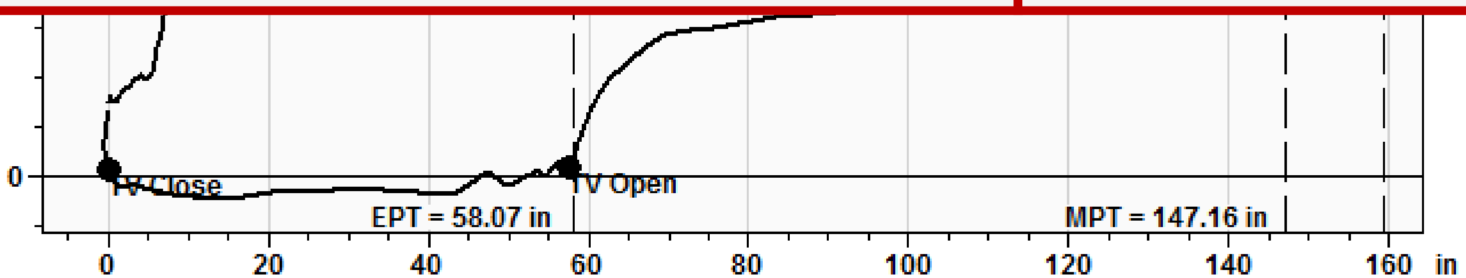
Pump	in	BBL/D
Maximum Plunger Travel	147.16	
Free Gas in Pump at Intake	99.02	144
Effective Plunger Stroke	58.07	85
Free Gas in Pump at Discharge	9.93	14
TV Close Delay	-0.03	-0
Slippage (Patterson)	5.07	7
Pump Displacement	43.10	63

Liquid	Pump Discharge BBL/D	(Calc) Surface Stock Tank BBL/D	(Input) Surface Stock Tank BBL/D
Oil	63	55	20
Water	0	0	0
Total Liquid	63	55	20

12 Hour Run Time

Pump	in	BBL/D
Maximum Plunger Travel	147.16	
Free Gas in Pump at Intake	99.02	72
Effective Plunger Stroke	58.07	42
Free Gas in Pump at Discharge	9.93	7
TV Close Delay	-0.03	-0
Slippage (Patterson)	5.07	4
Pump Displacement	43.10	31

Liquid	Pump Discharge BBL/D	(Calc) Surface Stock Tank BBL/D	(Input) Surface Stock Tank BBL/D
Oil	31	28	20
Water	0	0	0
Total Liquid	31	28	20



Stroke: 73 00:13:06

Unanchored Kt 402 lb/in Kr 156 lb/in

Annotations

Pump Card Analysis

EXCEL Spreadsheet Available on USB: "Pump Slippage Calculator_SPM_PattersonEq.xls"

$$Slippage = \left[(0.14 \cdot SPM) + 1\right] 453 \frac{DPC^{1.52}}{L\mu}$$

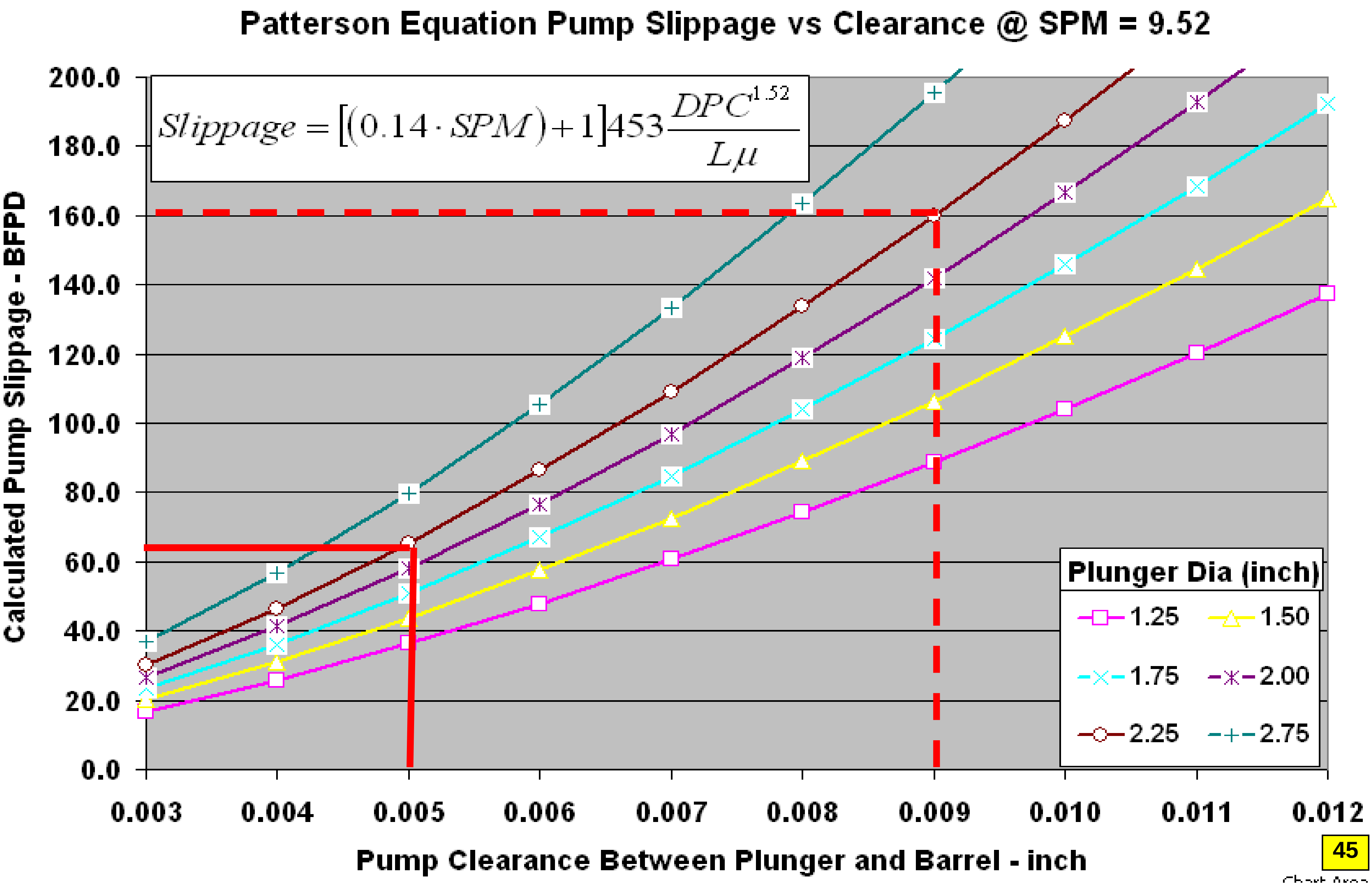
Inputs to Pump Slippage Calculations

D=Plunger Diameter (inches)	2.25
*P=Pressure Differiential	3155
C=Clearance (inches)	0.009
u=Fluid Viscosity (centipoise)	0.76
Plunger length (inches)	48
Strokes per Minute	9.52

*Calculating Differential Pressure

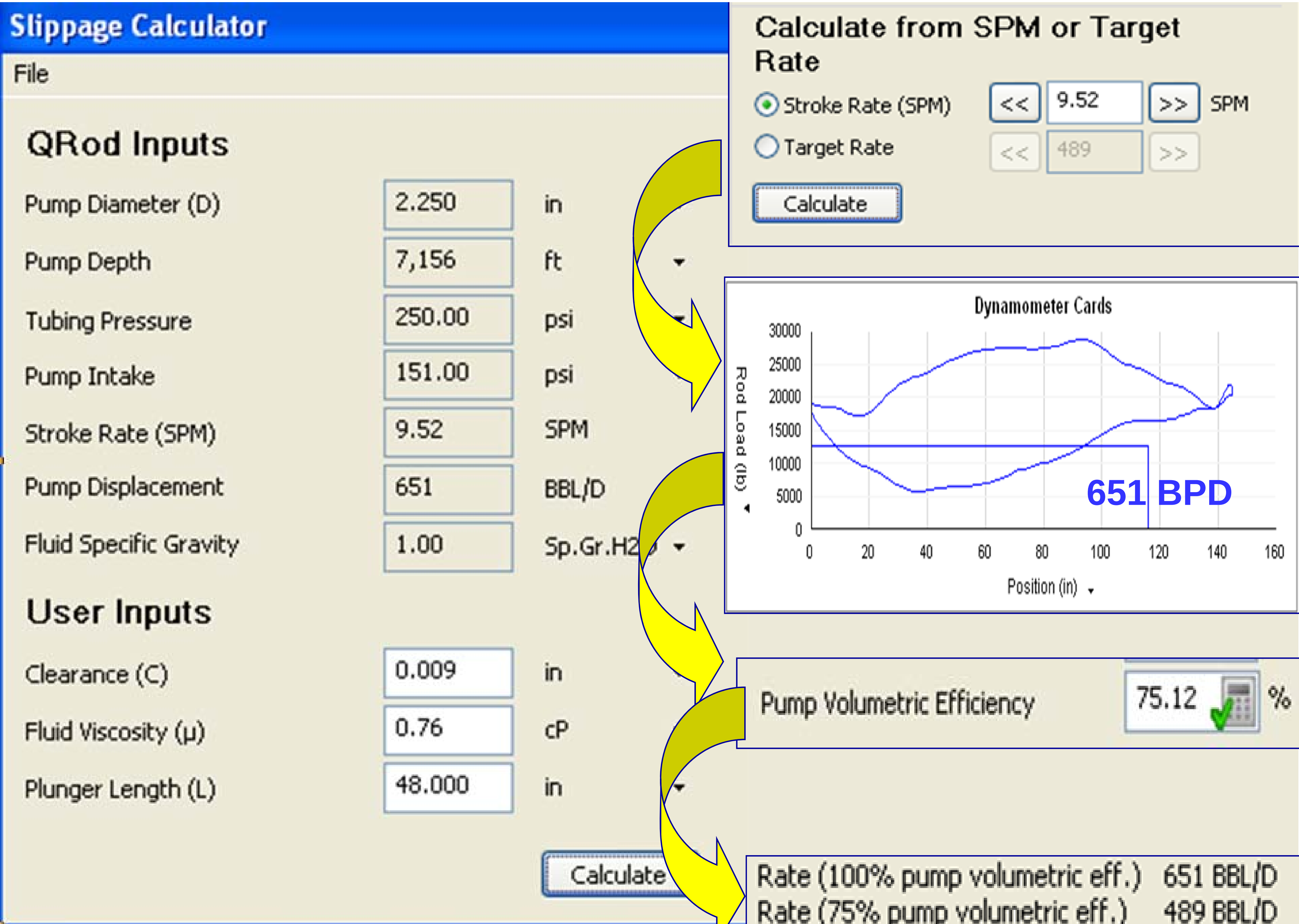
Pump Depth	7156
Tubing Discharge Pressure (Psi)	250
Tubing Fluid Gradient (Psi/Ft)	0.4271
Pump Intake Pressure (Psi)	151
Input your production rate, BPD	580.0
Slippage in BPD	159.8

Design Pump Clearance of 0.005” to Achieve 90% Pump Efficiency with 65 BPD Slippage

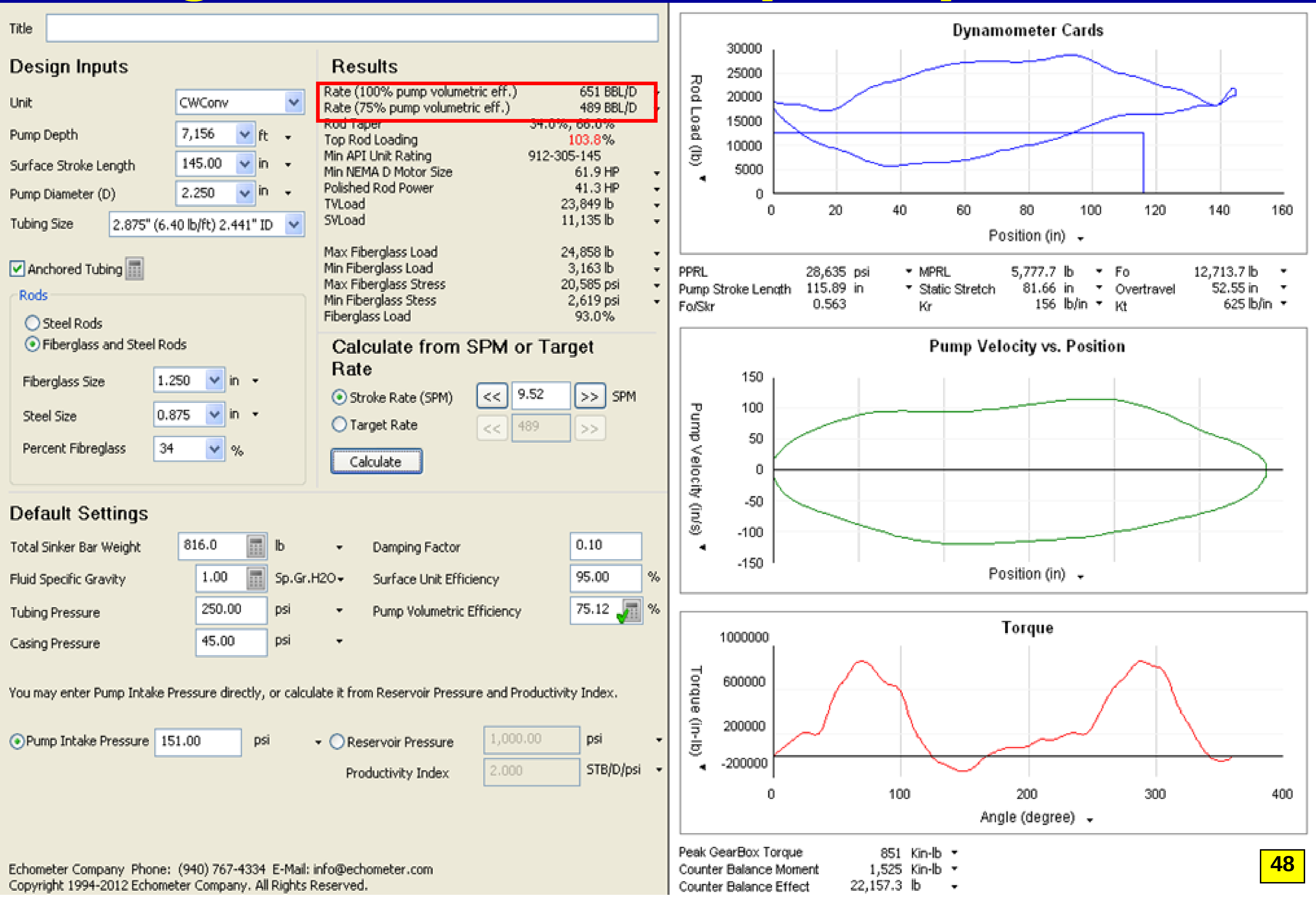


Recommended Procedure to Select Pump Clearances

1. **Use predictive sucker rod design program to calculate pump displacement, assume 100% liquid pump fillage.**
2. **Input correct well parameters into QRod Tool - "Pump Slippage Calculator", be sure to adjust water viscosity for the temperature at the pump**
3. **Examine Plot of "Patterson Equation Pump Slippage vs Clearance" and select pump clearance that gives the desired percentage of pump slippage.**


Slippage Calculator
File
QRod Inputs
Pump Diameter (D) 2.250 in
Pump Depth 7,156 ft
Tubing Pressure 250.00 psi
Pump Intake 151.00 psi
Stroke Rate (SPM) 9.52 SPM
Pump Displacement 651 BBL/D
Fluid Specific Gravity 1.00 Sp.Gr.H2O
User Inputs
Clearance (C) 0.009 in
Fluid Viscosity (µ) 0.76 cP
Plunger Length (L) 48.000 in
Calculate
Calculate from SPM or Target Rate
Stroke Rate (SPM) << 9.52 >> SPM
Target Rate << 489 >>
Calculate
Dynamometer Cards
Rod Load (lb)
Position (in)
651 BPD
Pump Volumetric Efficiency 75.12 %
Rate (100% pump volumetric eff.) 651 BBL/D
Rate (75% pump volumetric eff.) 489 BBL/D

Design 651 BPD Pump Displacement



Slippage Calculator

File

Patterson Slippage 155.5 BPD

QRod Inputs

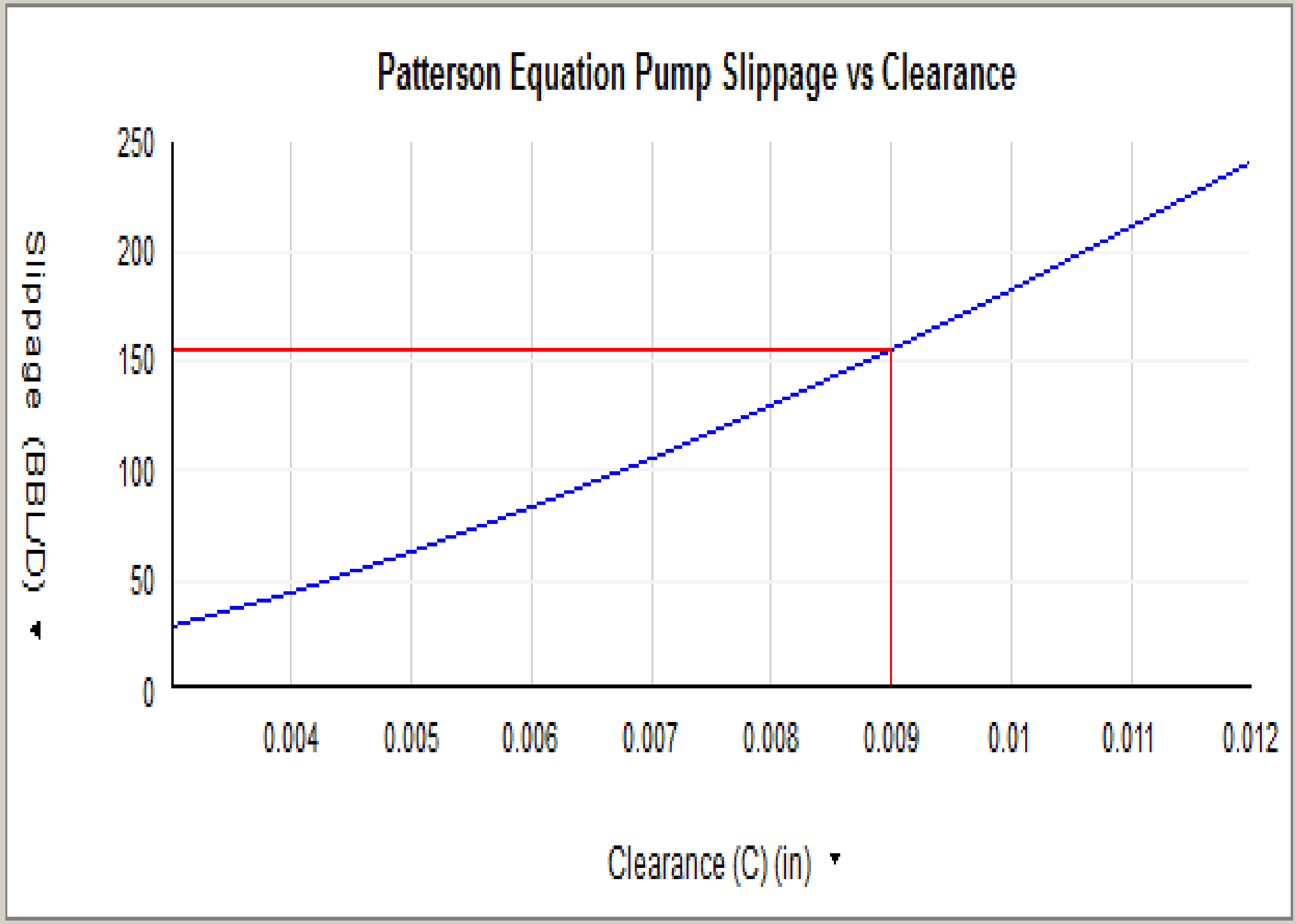
Pump Diameter (D)	2.250	in
Pump Depth	7,156	ft
Tubing Pressure	250.00	psi
Pump Intake Pressure	229.00	psi
Stroke Rate (SPM)	9.47	SPM
Pump Displacement	534.00	BBL/D
Fluid Specific Gravity	0.99	Sp.Gr.H2O

User Inputs

Clearance (C)	0.009	in
Fluid Viscosity (μ)	0.76	cP
Plunger Length (L)	48.000	in

Calculate

Slippage	155.47	BBL/D	Pressure Differential (P)	…78.96	psi
Pump Volumetric Efficiency	70.89	%	Tubing Fluid Gradient	…985701	psi/ft



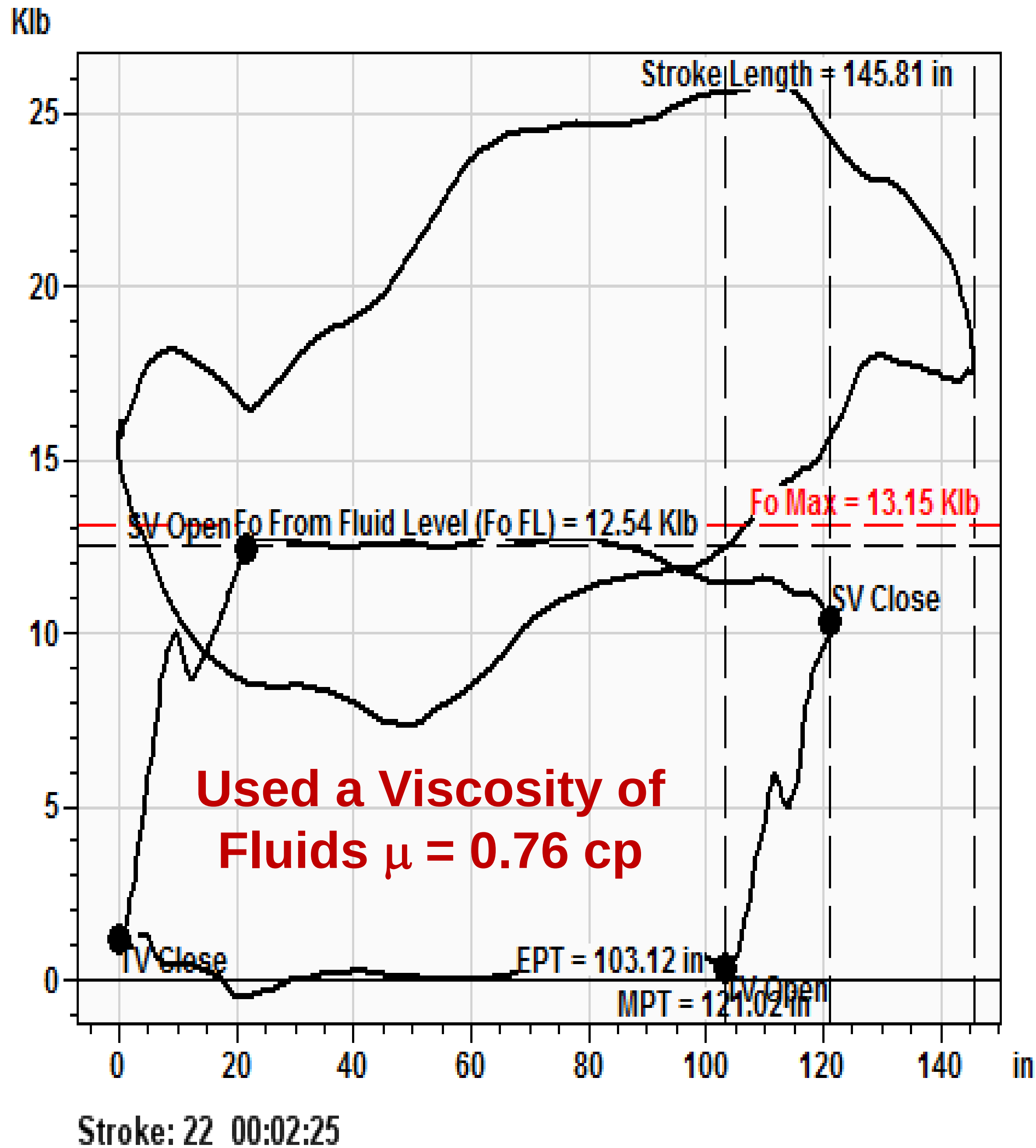
$$Slippage = \left[\left(0.14 \cdot SPM\right)+1\right]453\frac{DPC^{1.52}}{L\mu}$$

Use Calculation

Cancel

Field Example of 0.009 Pump

Why only 402 barrels per day is being produced to the tank, when the effective downhole pump displacement is 577 BPD?



1. **New pump w/ no wear or damage**
2. **Installed 0.009 in. clearance w/ 2.25 inch diameter & 4 foot plunger**
3. ***<u>Patterson Eq. Slippage 155 BPD</u>***
4. **576 BPD Full Pump dynamometer card (No correction for slippage or gas in solution).**
5. **Tested Rates are 106 BOPD & 296 BWPD ~ 26.4% Oil**
6. **Production is 175 BPD less than the 577 BPD pump displacement.**
7. **(106+296)/577 = *<u>70% Pump Eff.</u>***
8. **14 MscfD gas up tubing (245 GOR), at 3307 psi discharge pressure, then water swelled 1.7% due P&T. Oil swelled 6.8% due to P&T and gas in solution. Liquid from P&T and solution gas looses 12 BPD.**
9. **Patterson Equation appears to calculate slippage fairly accurately.**

Measured Rate Matches Calculated

Pump

	in	BBL/D
Maximum Plunger Travel	121.02	
Free Gas in Pump at Intake	18.84	105
Effective Plunger Stroke	103.12	577
Free Gas in Pump at Discharge	0.93	5
TV Close Delay	0.00	0
Slippage (Patterson)	27.80	155
Pump Displacement	74.39	416

Viscosity of Fluids
μ = 0.76 cp

Liquid

	Pump Discharge BBL/D	(Calc) Surface Stock Tank BBL/D	(Input) Surface Stock Tank BBL/D
Oil	110	103	106
Water	306	301	296
Total Liquid	416	404	402

How to Use

- **Troubleshoot when Adj Pump Displacement does not match what's produced into tank.**
- **Determine Pump Wear and Wear Rate as Equipment Operates in the Well**
- **Design Pump Clearance for New Installation to Match Inflow from Well**
- **As Pump Wears Increase SPM to Maintain Full Pump and Obtain Long Run Life**
- **Know Expected Performance of Every Well**

Conclusions

- Knowing the Amount Of Gas Pumped Into the Tubing Helps Determine Tubing Fluid Gradient
- Representative Dynamometer Card should be Selected for Analysis, if You Wish to Match Calculated Production to Reported Production
- More Input Data is Required to make Calculation Work
- Pump Clearance is Difficult to Find Out
- Differences between Liquid in the Tank and Pump Displacement from EPT, NOW easier to explain.
- Difference from MPT and Equivalent Gas Free Pump Fillage Equals Displacement Consumed by Free Gas
- Equivalent Gas Free Pump Fillage Line Helps Trouble Shoot Sucker Rod Lifted Wells

Recommendation

Handbook for those that would like to learn more, please click on following link:

https://www.amazon.com/Acoustic-Fluid-Level-Measurements-Handbook/dp/0886982790/ref=sr_1_1?s=books&ie=UTF8&qid=1505073594&sr=1-1&keywords=Acoustic+fluid+level+handbook

to "Acoustic Fluid Level Measurements in Oil and Gas Wells Handbook Paperback – January 1, 2017" by Dr. A. L. Podio (Author), Jim McCoy (Author)

A comprehensive technical handbook that discusses the importance, application, and interpretation of acoustic fluid level measurements for all types of wells and measurement instrumentation, ranging from strip charts to digital sensors.