



4th Annual Sucker Rod Pumping Workshop

Hilton North Hotel, Houston, Texas

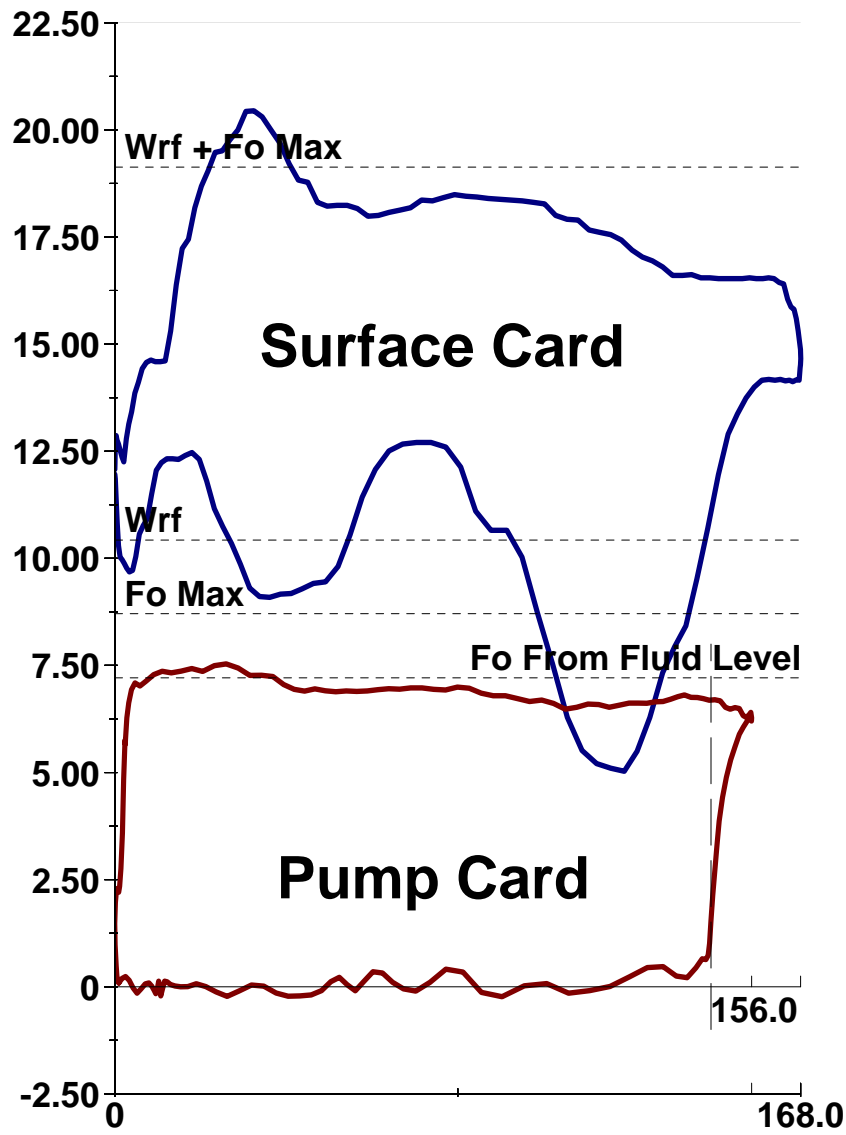
September 9 – 12, 2008

Reference Loads for the Downhole Pump Card

Lynn Rowlan

(((ECHOMETER)))

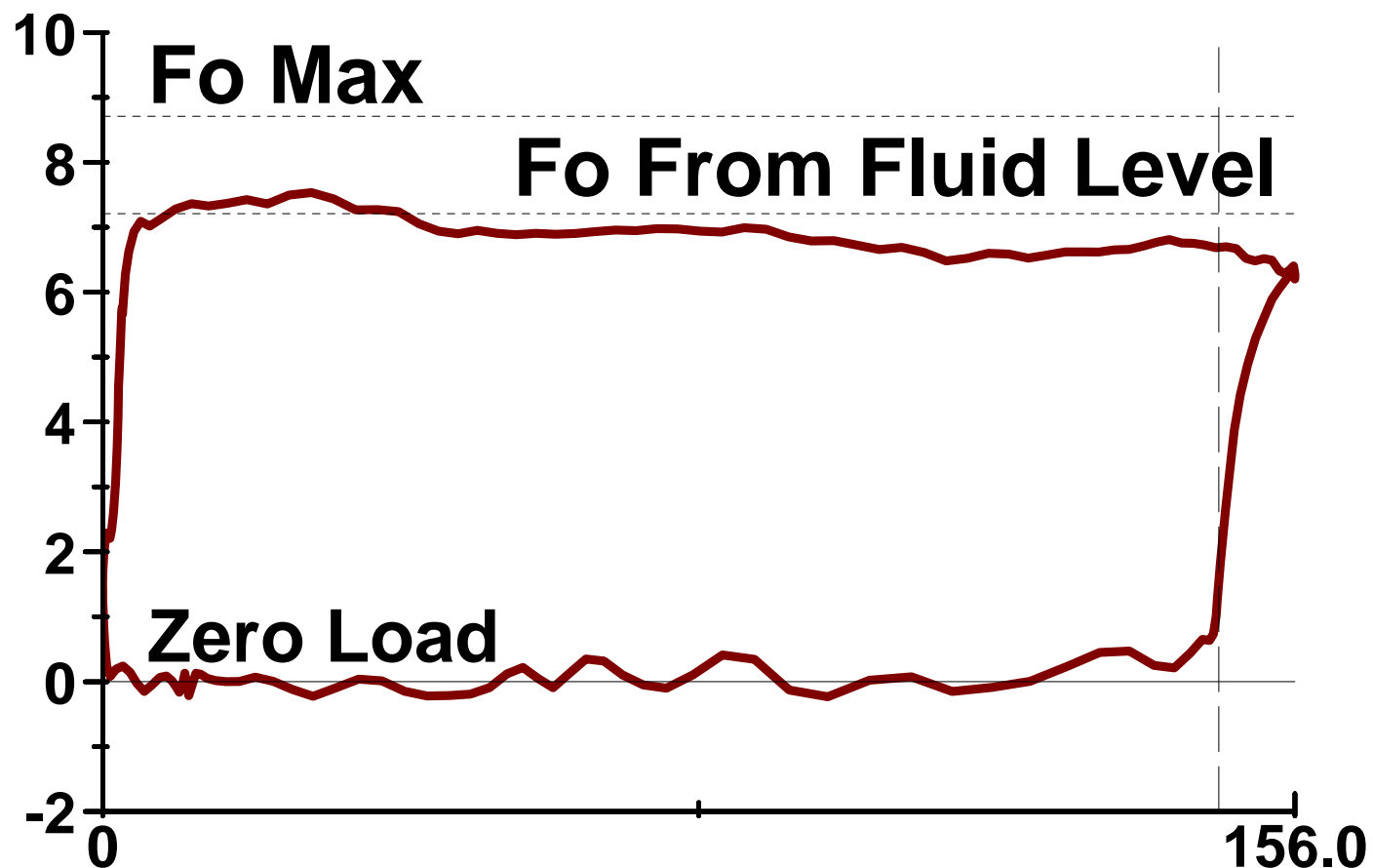
Dynamometer Card Definition



- 1) Surface dynamometer card is the plot of the measured rod loads at the various positions throughout a complete stroke; the load is usually displayed in pounds of force and the position is usually displayed in inches.
- 2) Pump dynamometer card is a plot of the calculated loads at various positions of pump stroke and represents the fluid load the pump applies to the bottom of the rod string.

Reference Loads for the Downhole Pump Card

Understanding the pump card basic loads is critical to analyzing and troubleshooting downhole problems:



Pump Card Reference:

Zero Load Line ~ Down Stroke
Fo From Fluid Level ~ Up Stroke

Normal Pump Card Loads:

SV Open Upstroke:

$$Fo \text{ Max} = (P_{dis} - 0) * A_p$$

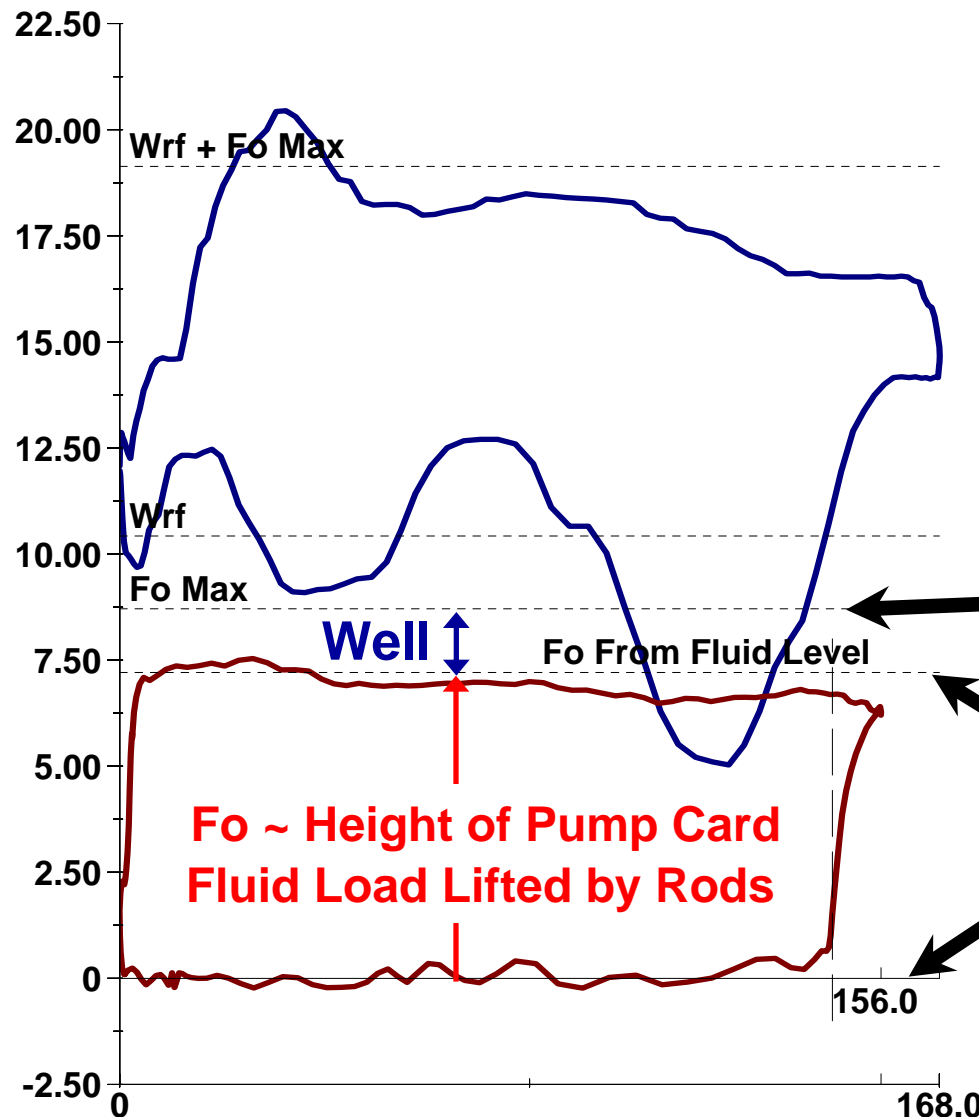
$$Fo = (P_{dis} - P_{intk}) * A_p$$

TV Open Downstroke:

$$Fo = 0$$

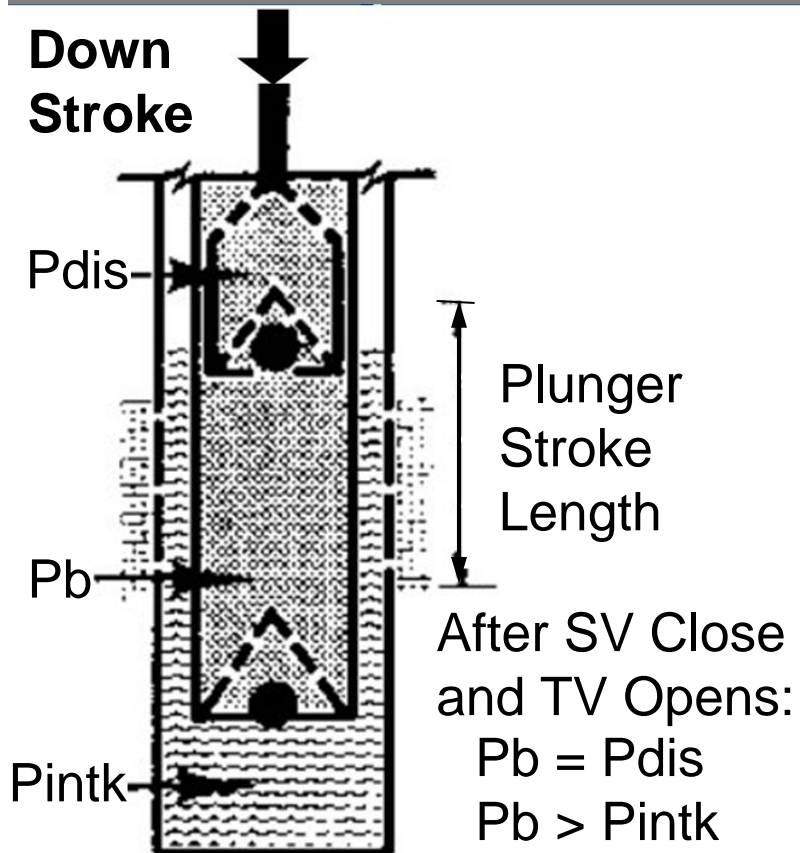
Reference Lines:

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 - assumes pressure above and below the plunger are equal; no friction due to fluid displacing through SV on down stroke

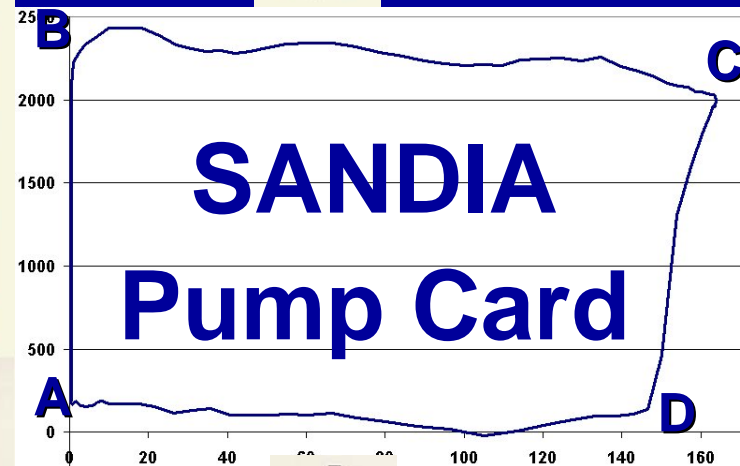


Zero Load Line

Load Reference Line ~ Down Stroke



Steps in the Pump Operation

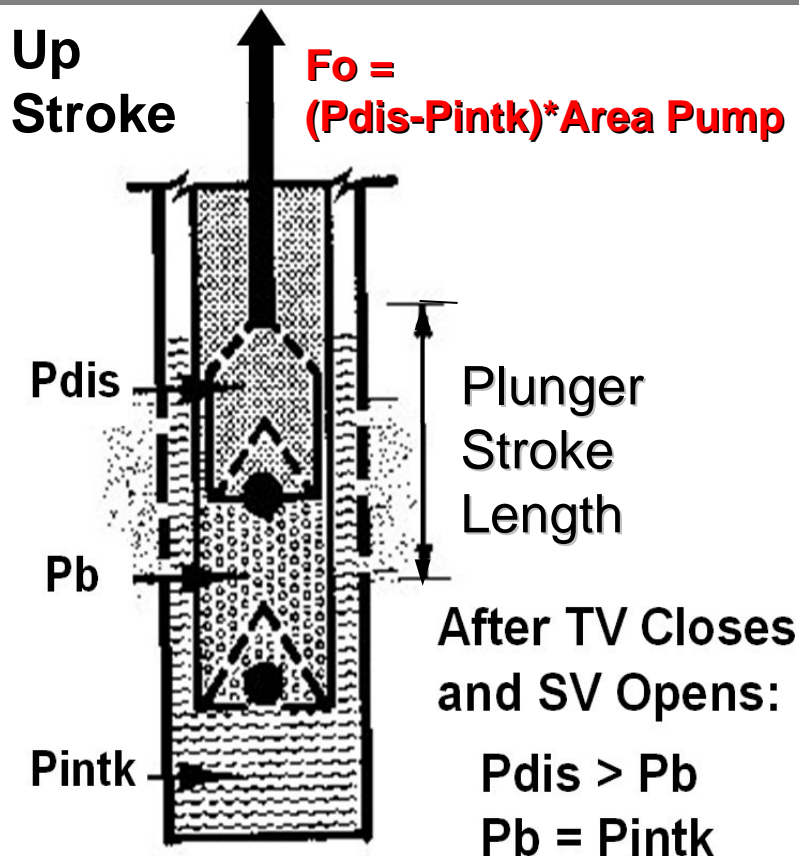


D) Pump discharge pressure (P_{dis}) equals the static tubing pressure (P_b), and the traveling valve opens. P_{dis} now carried by tubing.

D - A, the fluid in the pump is displaced through the traveling valve into the tubing and **ZERO** fluid load is on rods.

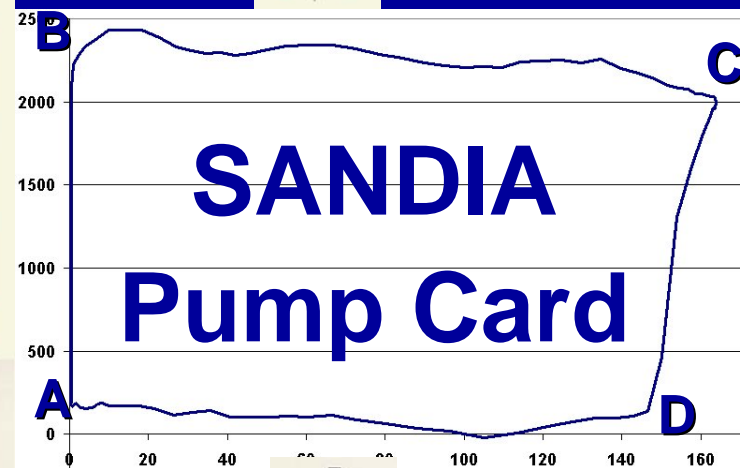
Fo From Fluid Level

Load Reference Line on Up Stroke

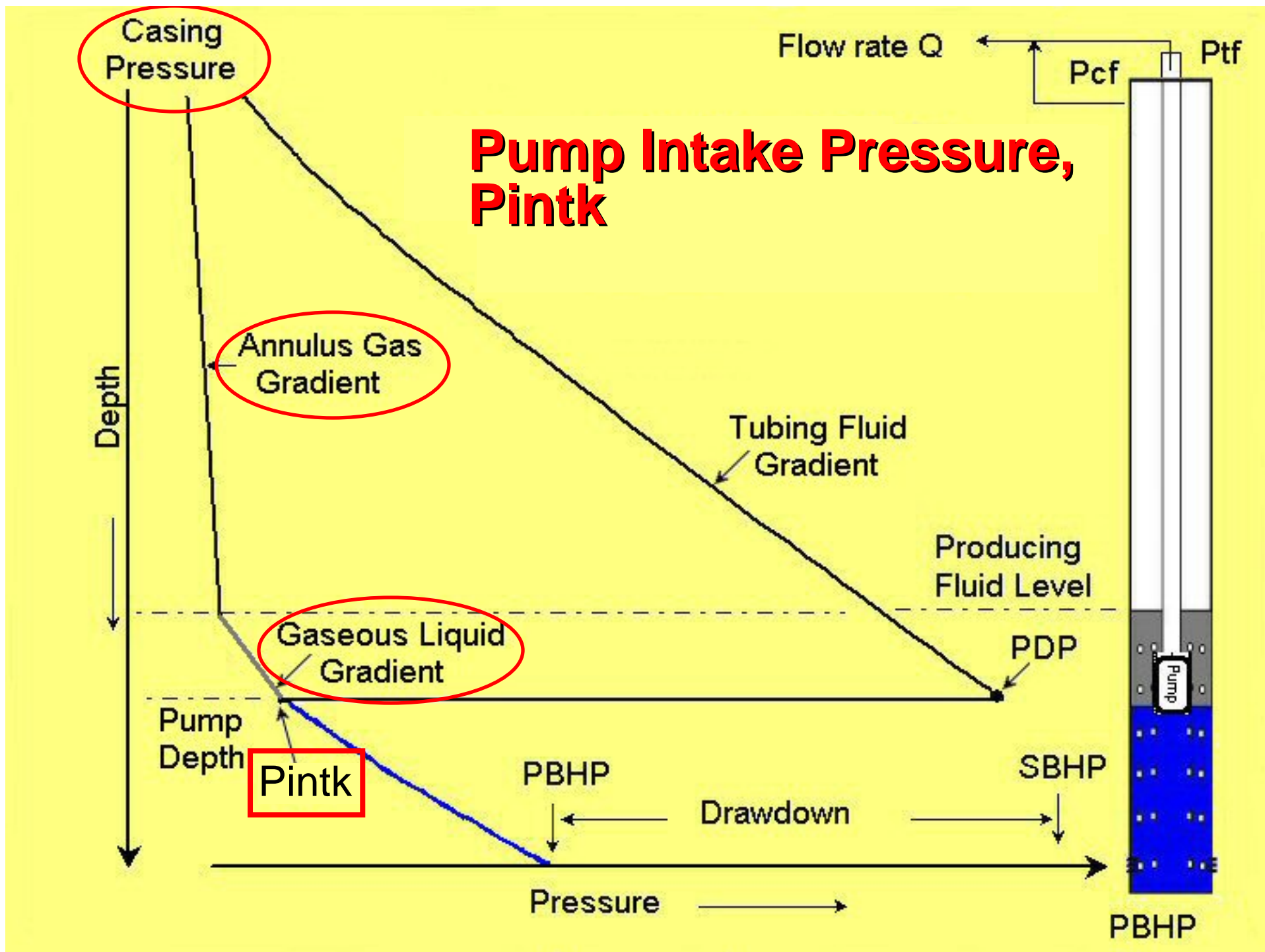


Steps in the Pump Operation

- B) Standing Valve opens, when rods stretch to pick up fluid load, F_o , from tubing.
- C) Standing valve closes.

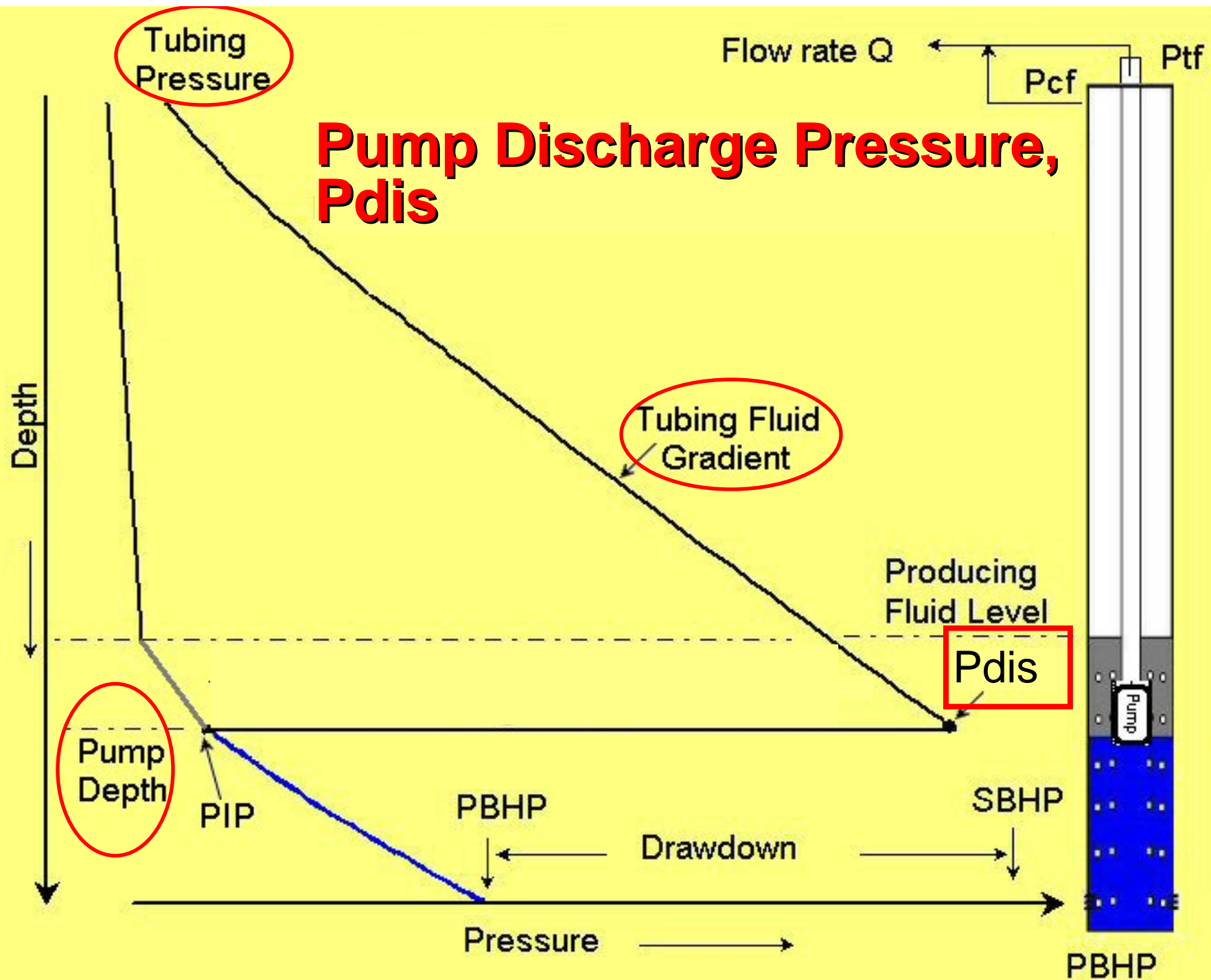


B-C) Plunger applies Fluid load, F_o , to the rods as well fluids are drawn into the pump.



Acoustic PIP Calculation

- Requires stabilized conditions
- Determination of Liquid Level Depth
 - Avg. Joint Length, Acoustic Velocity, SG Gas
- Measurement of casing pressure
- Tubing, Casing Size, & Pump Depth
- Oil, water and annular gas densities
- Measurement of casing pressure buildup rate (at Producing Conditions)

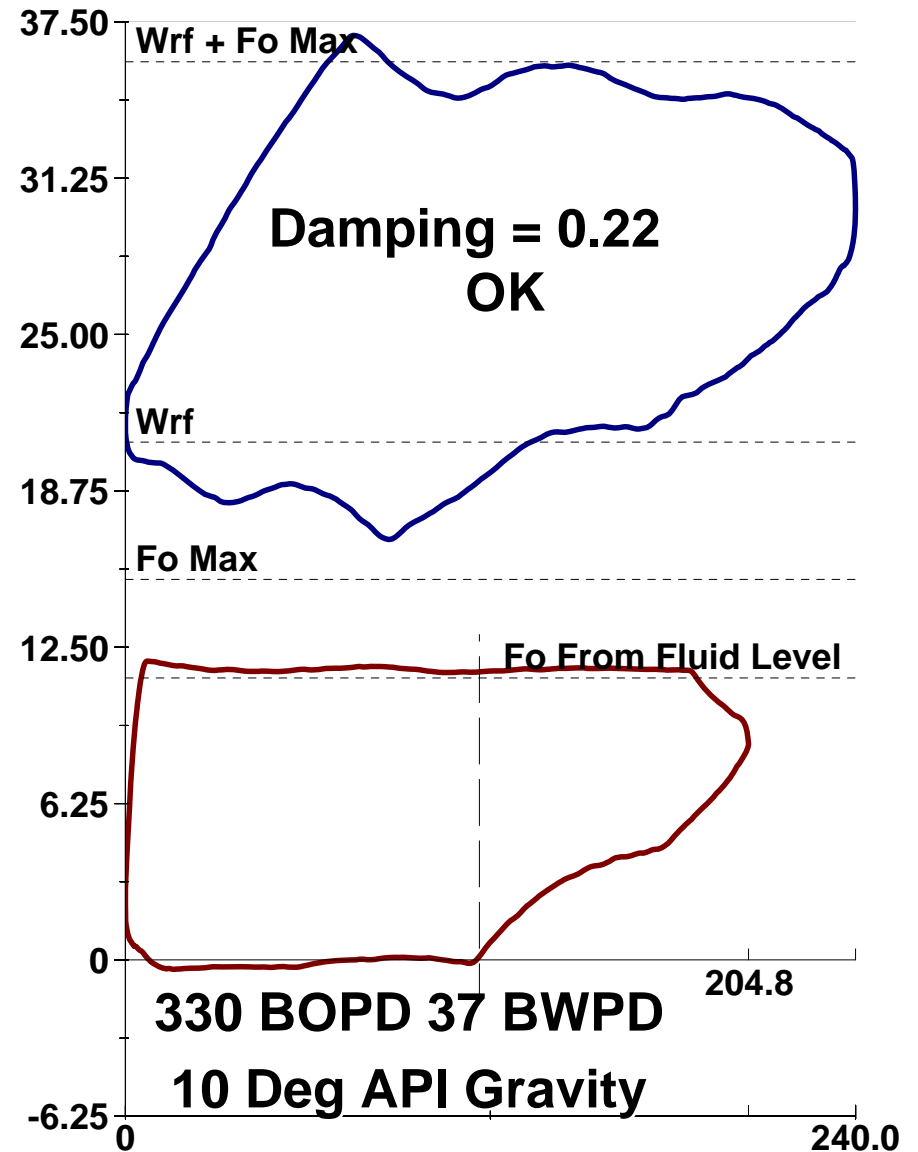
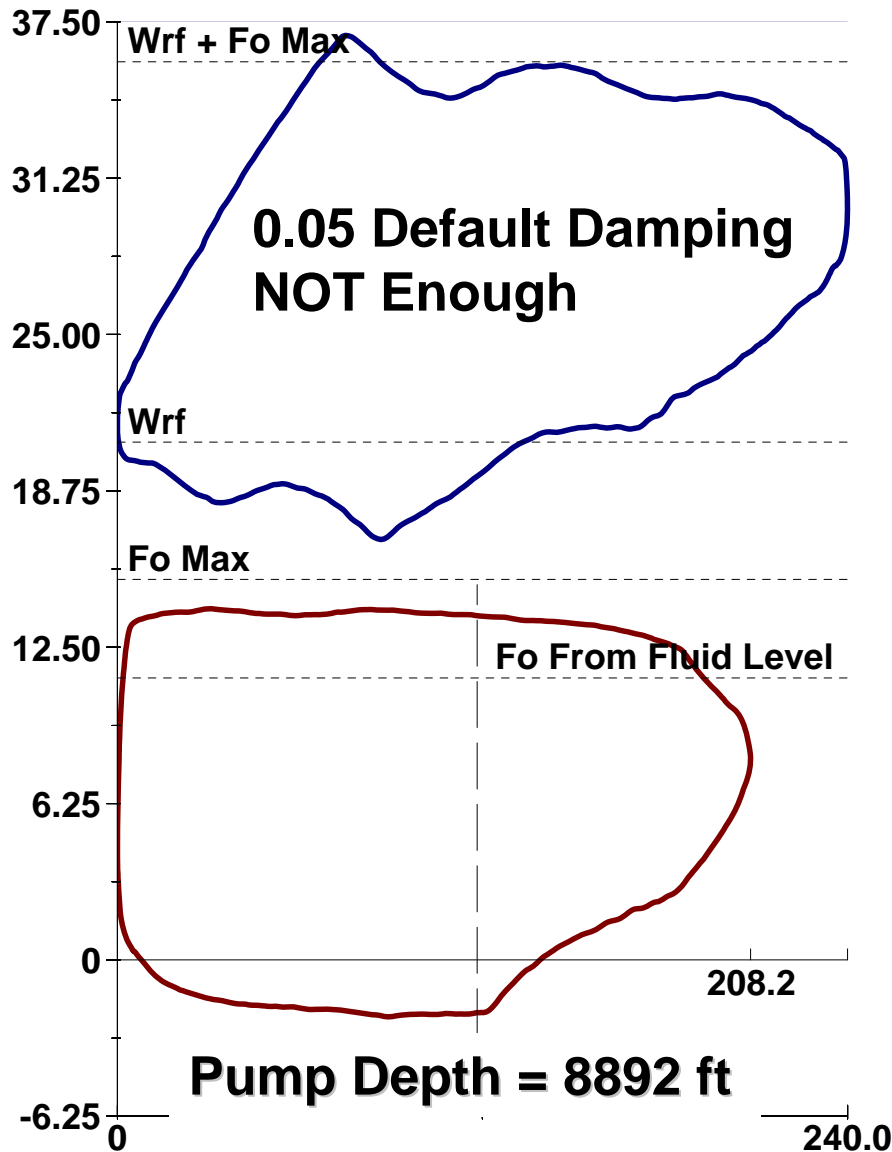


Pump Discharge Pressure

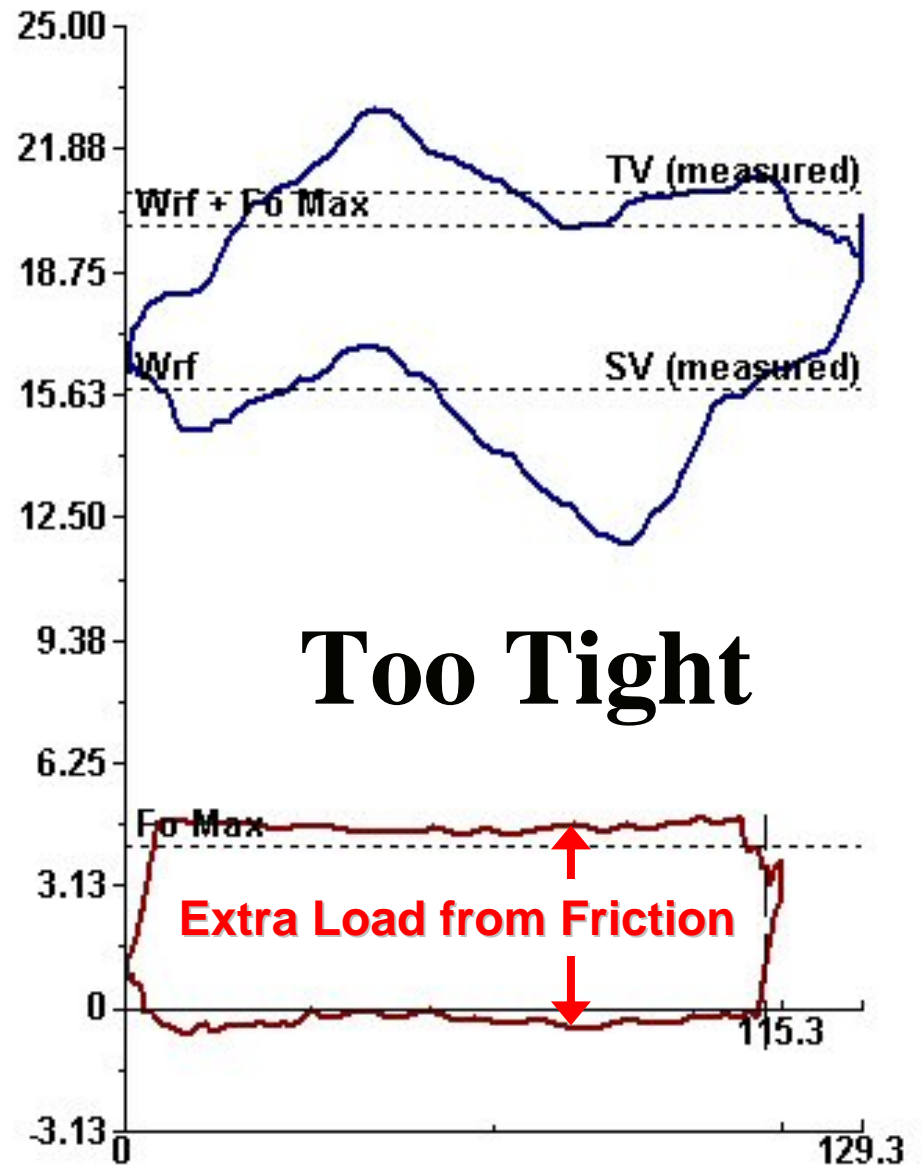
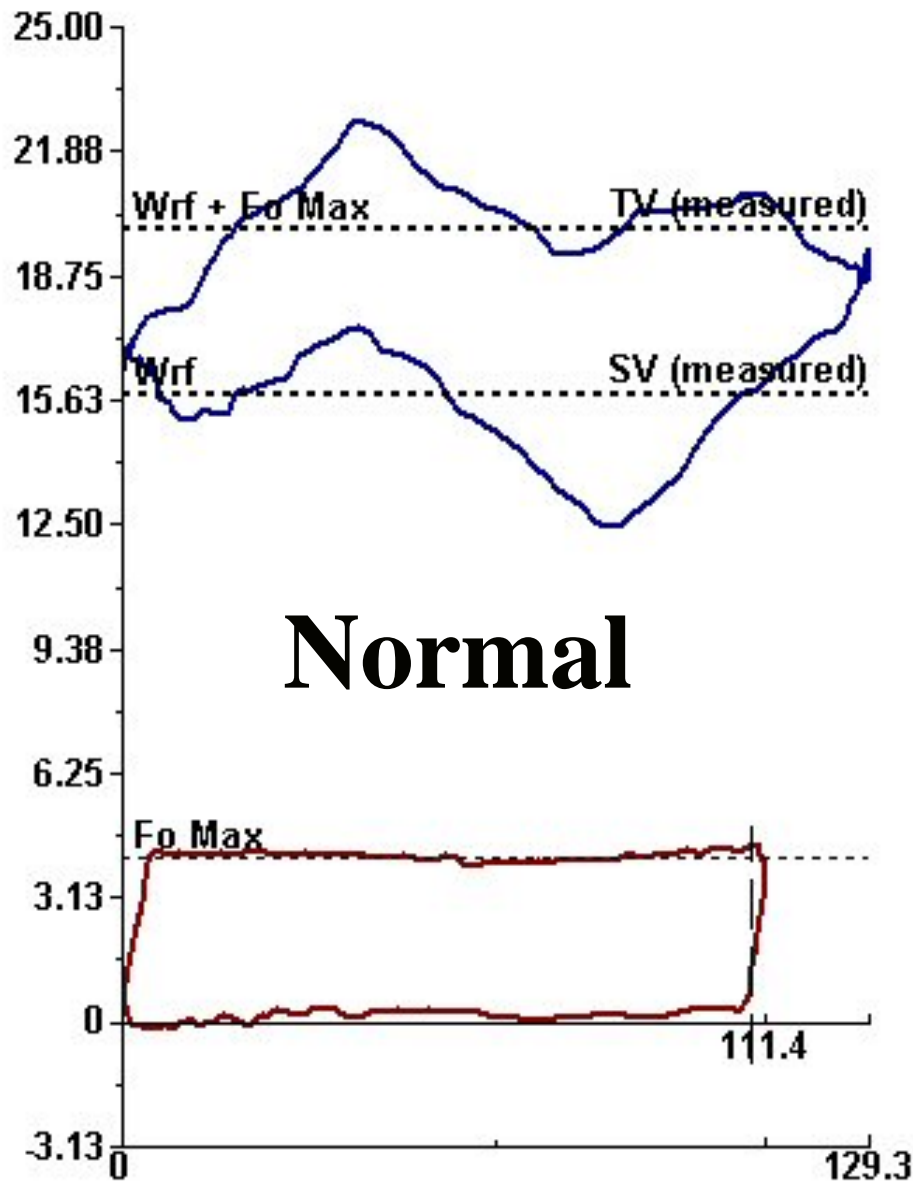
- Requires stabilized conditions
- Measurement of tubing pressure
- True Vertical Pump Depth
- Oil, water and gas densities
- Oil, water, and gas Production Rate
- Tubing Fluid Gradient

$$F_o = (P_{dis} - P_{intk}) * \text{Area Pump}$$

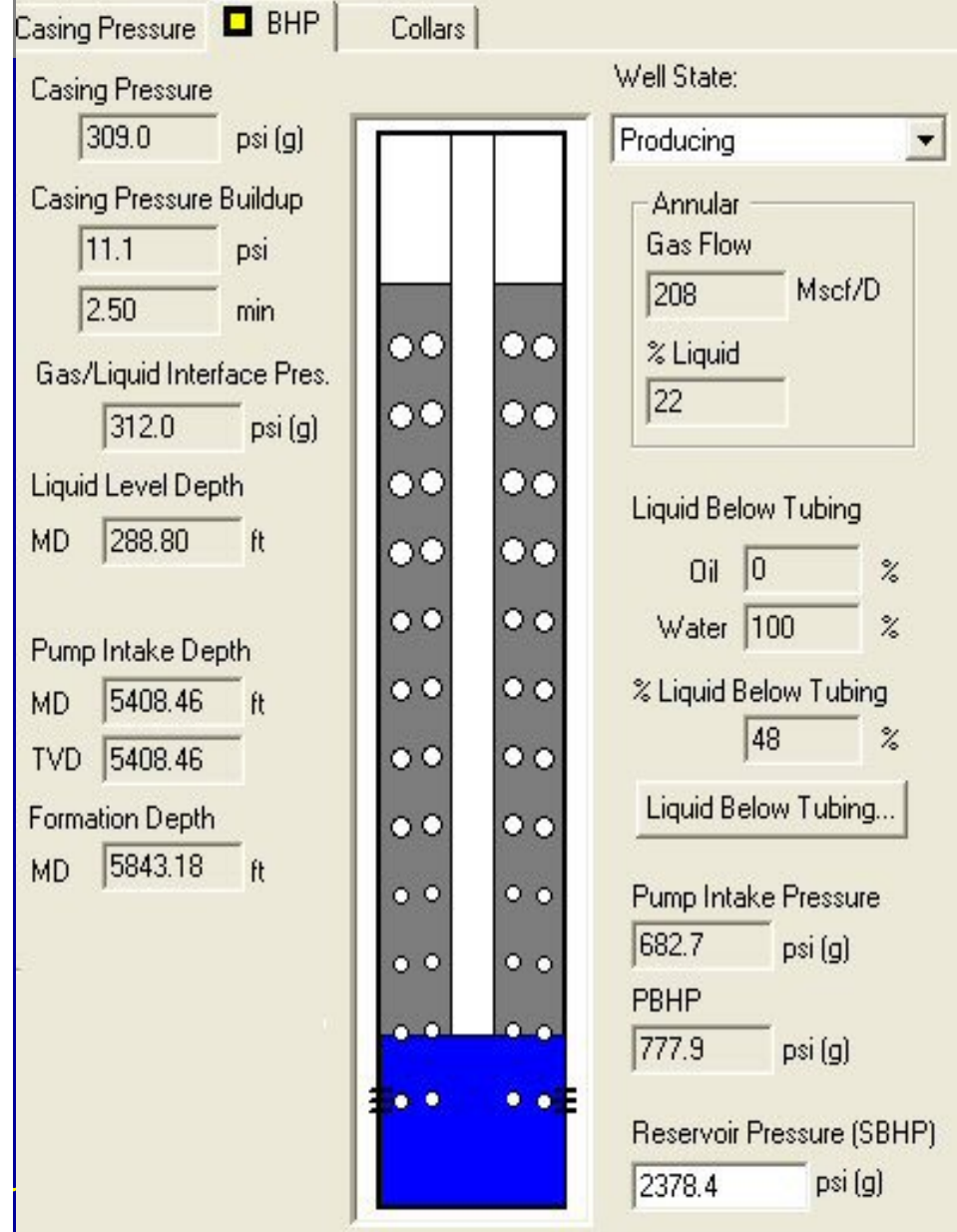
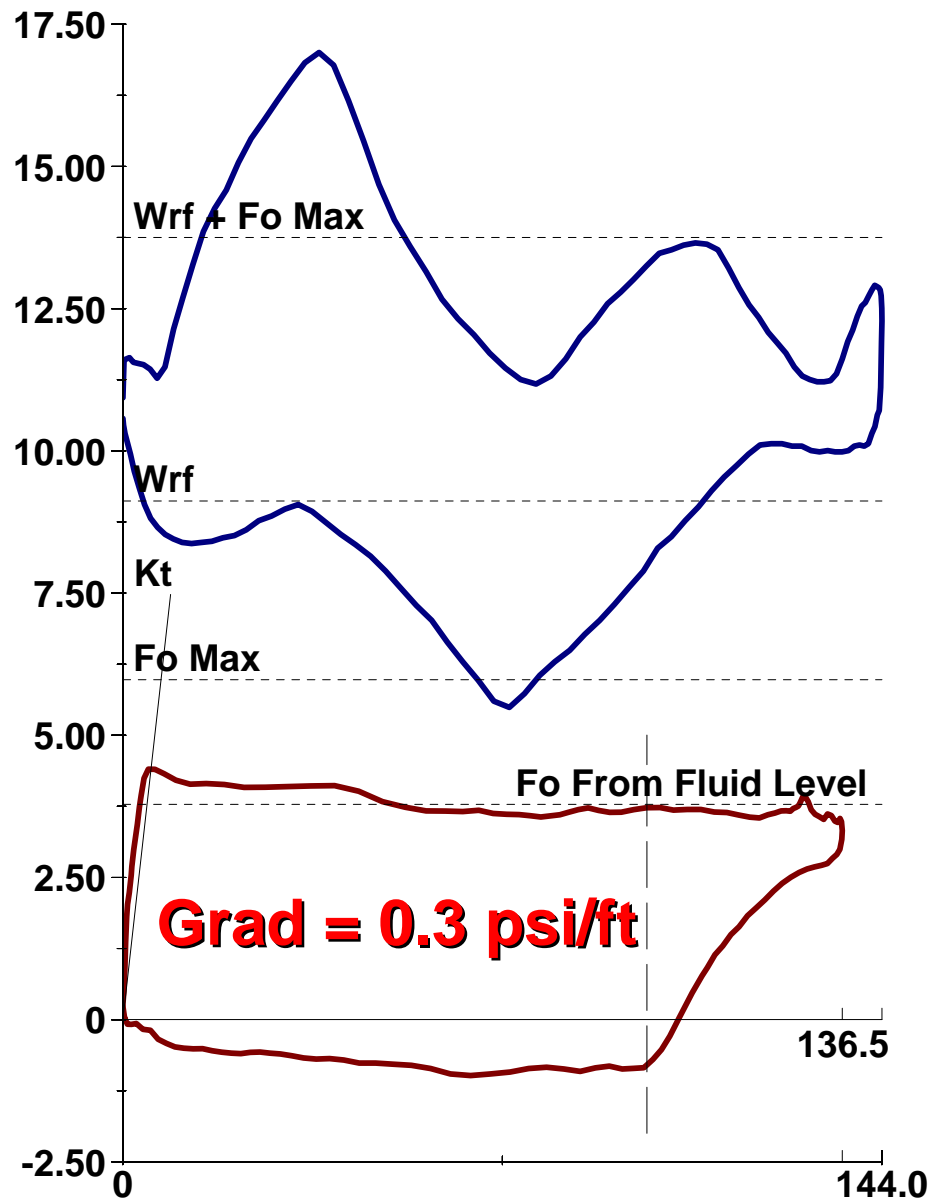
Damping Coefficients



Abnormal Loads – Tight Stuffing Box



Tubing Fluid Gradient – Wrf & Pdis

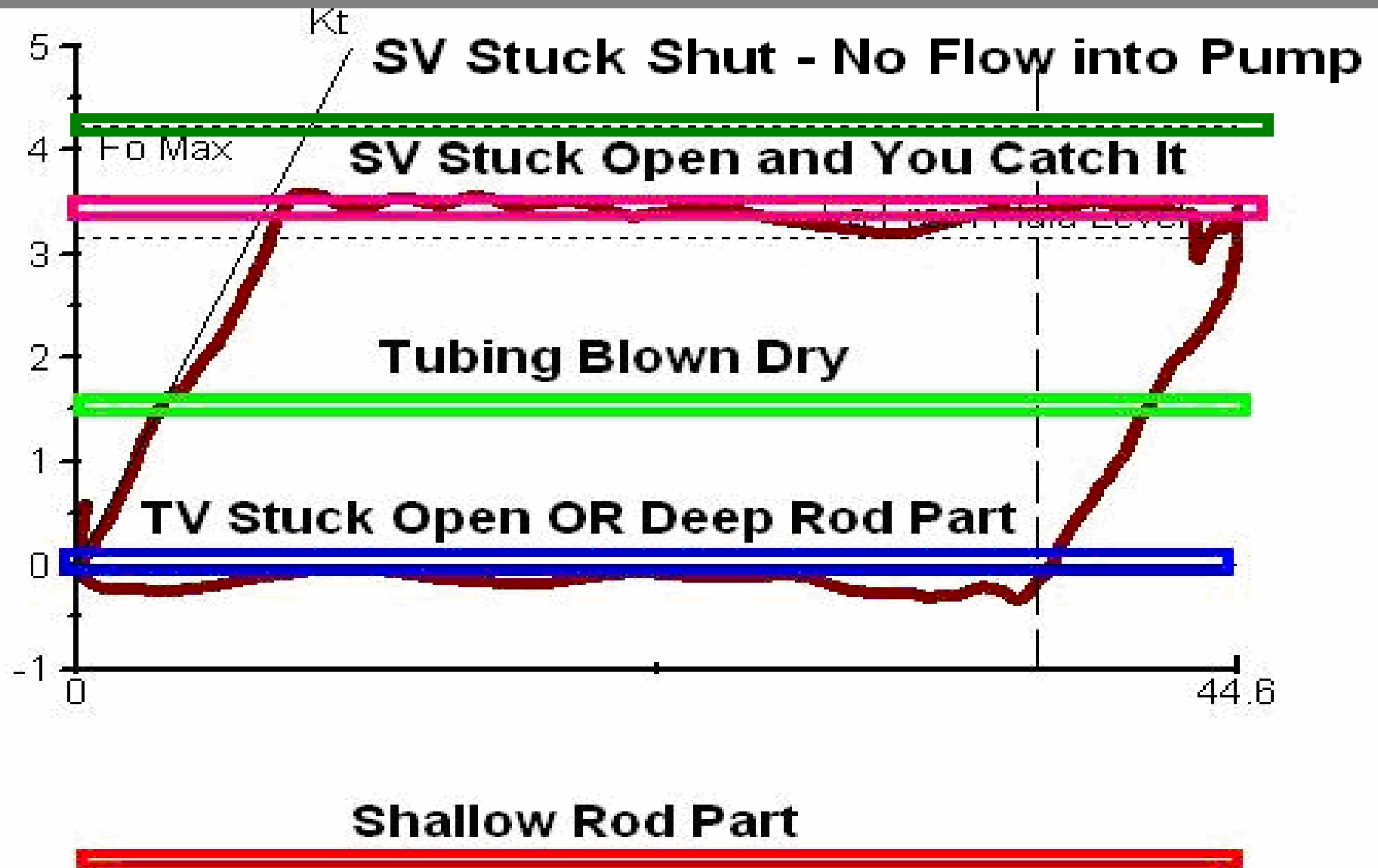


Flat Pump Card Load Lines

- 1) TV Stuck Open - Looks like Deep Rod Part but you can often tag or jar the rods and knock the debris out of the pump and re-start pump action.
- 2) Deep Rod Part – Plots on the Zero Load Line
- 3) Shallow Rod Part – Plots below the Zero Load Line by the amount of missing rod weight in fluid no longer attached to the polished rod.
- 4) Tubing Blown Dry – Plots as a flat line @ a height of Wra-Wrf pounds above the zero load line.
- 5) SV Stuck Open – Plots on the Fo from the Fluid Level line.
- 6) Blocked Intake – No fluid entry into pump and low slippage through pump clearances

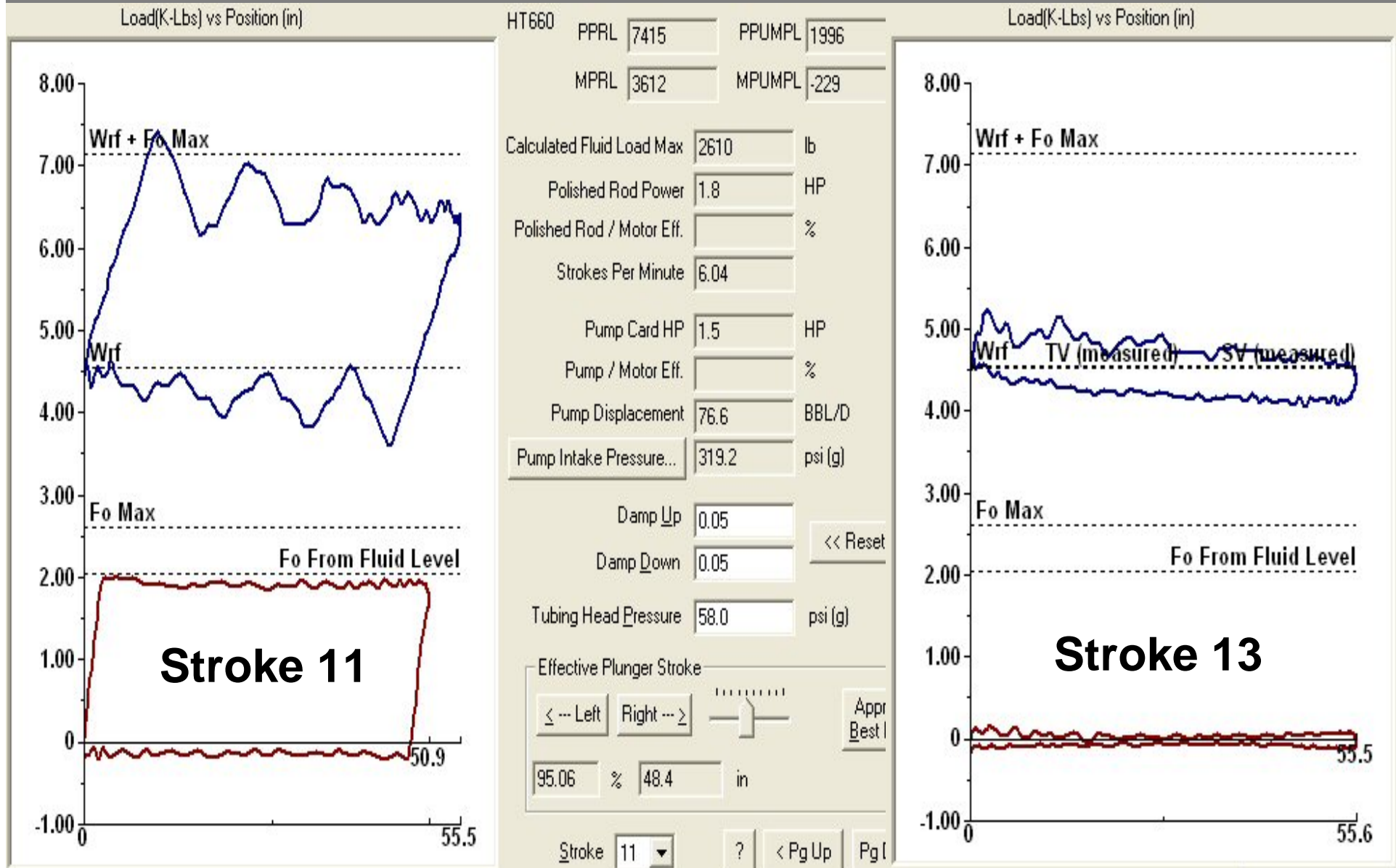
Horse Shoe Pump Card

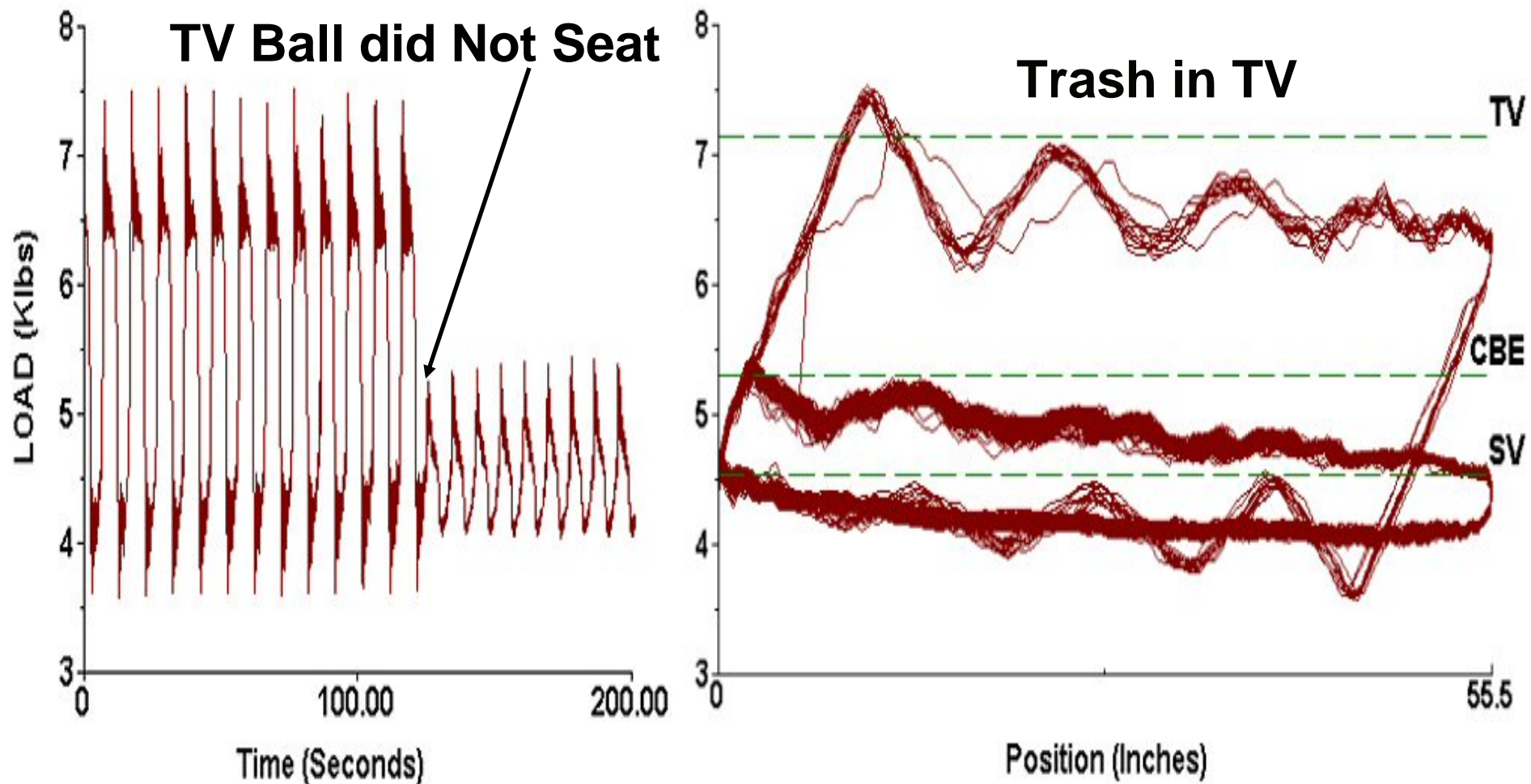
Flat Load Lines



Lost TV Load

Strokes 10 seconds apart.
Is this a deep Rod Part?

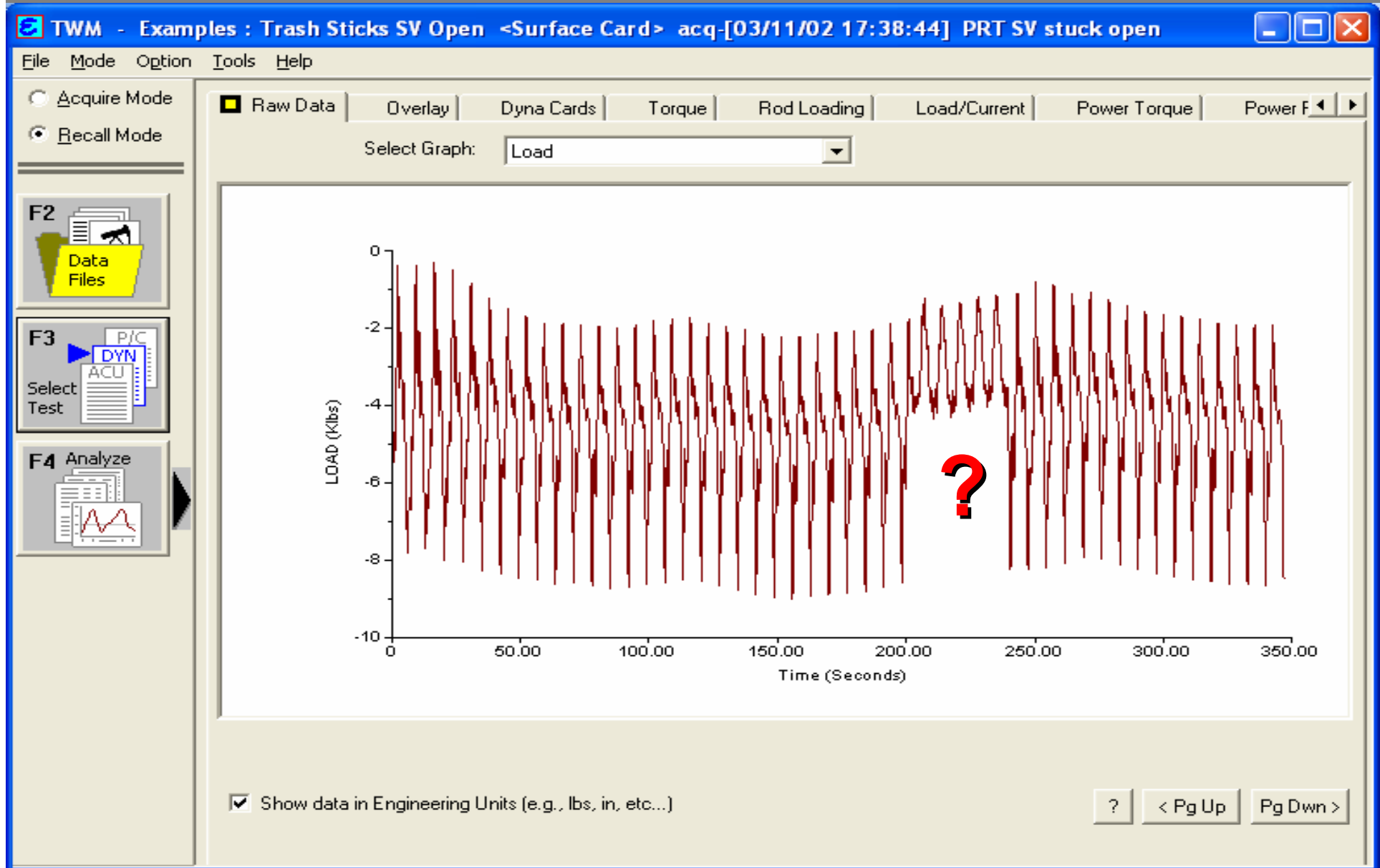




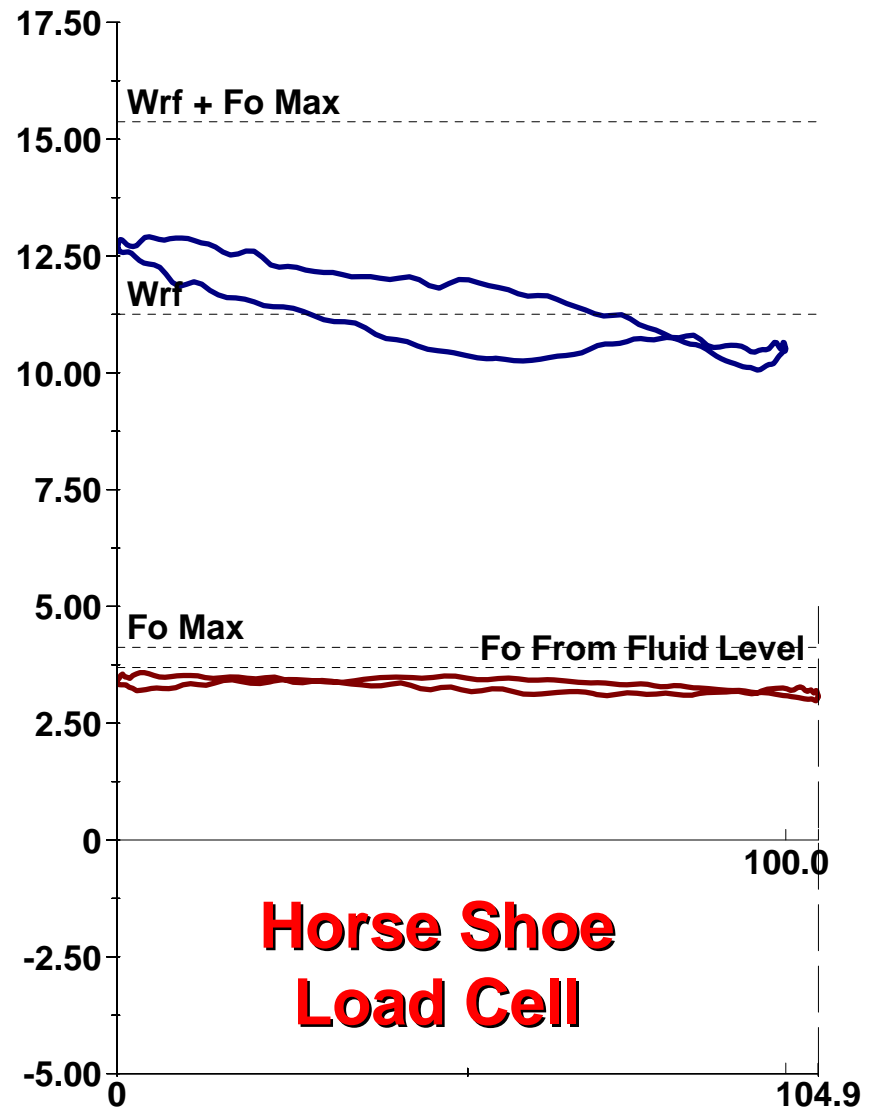
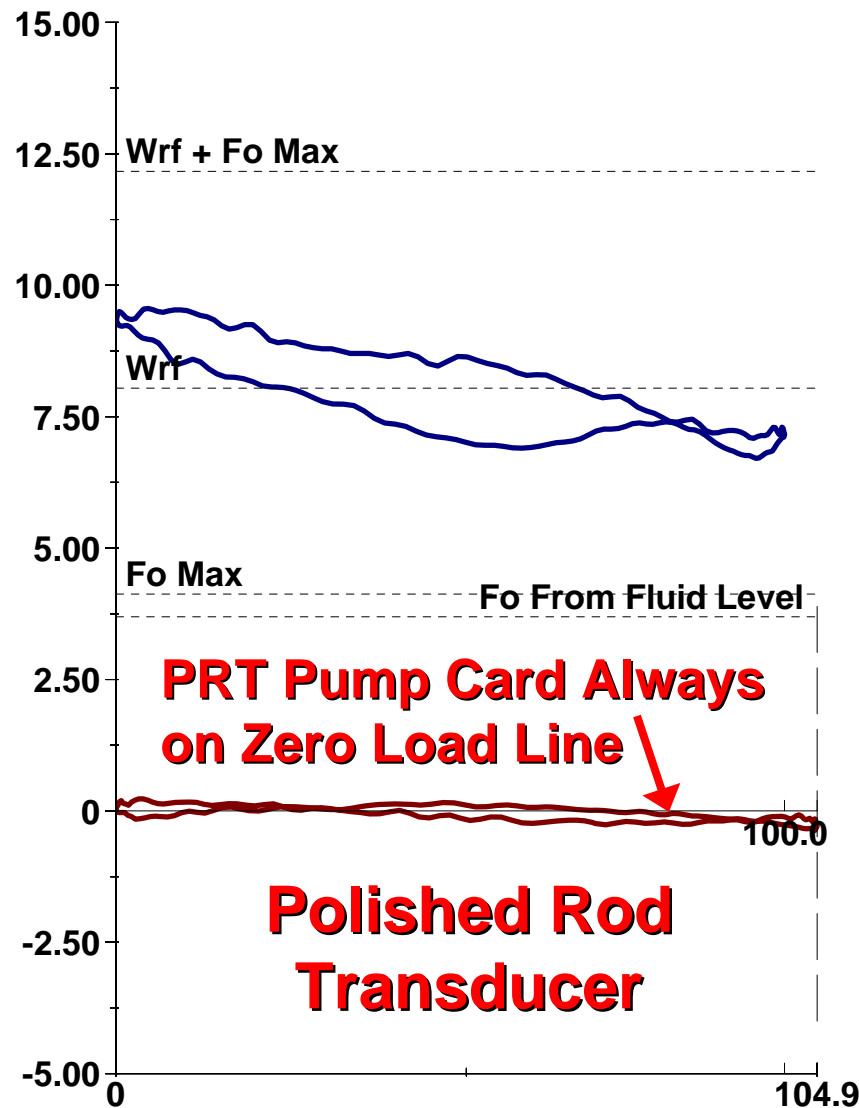
Trash in TV Notice normal appearing Surface Dynamometer Card, on the 13th stroke TV became stuck open due to trash. Same type of surface card could occur, if Pump unseated, Pull Rod became unscrewed or parted, or rods parted at the pump.

SV Sticks Open

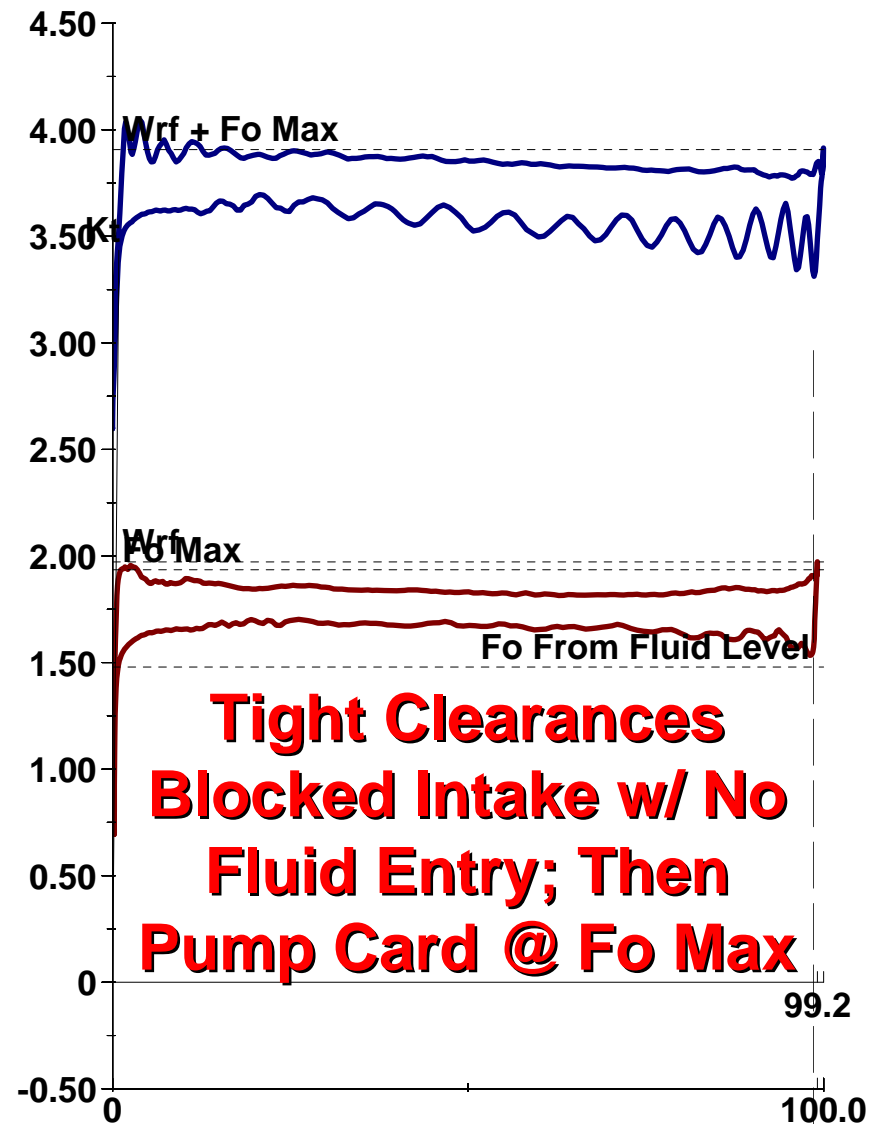
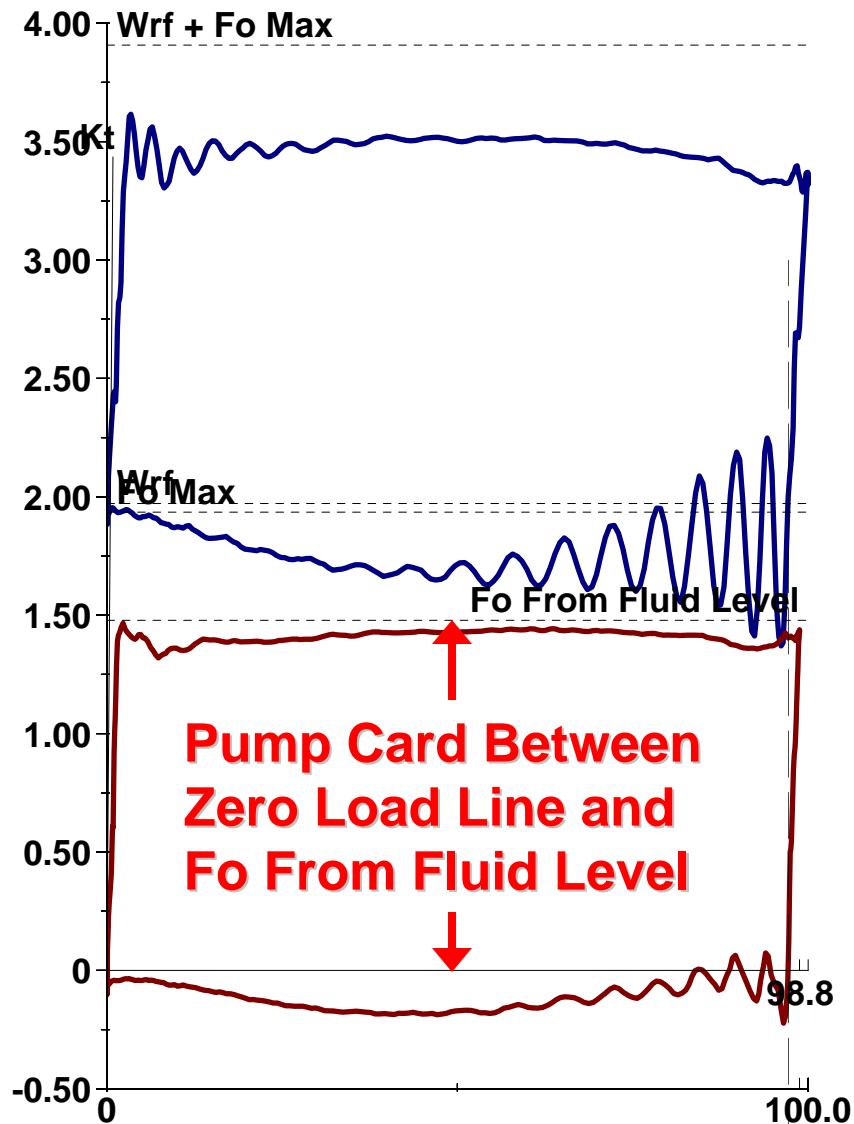
Strokes 29-34 SV Missing

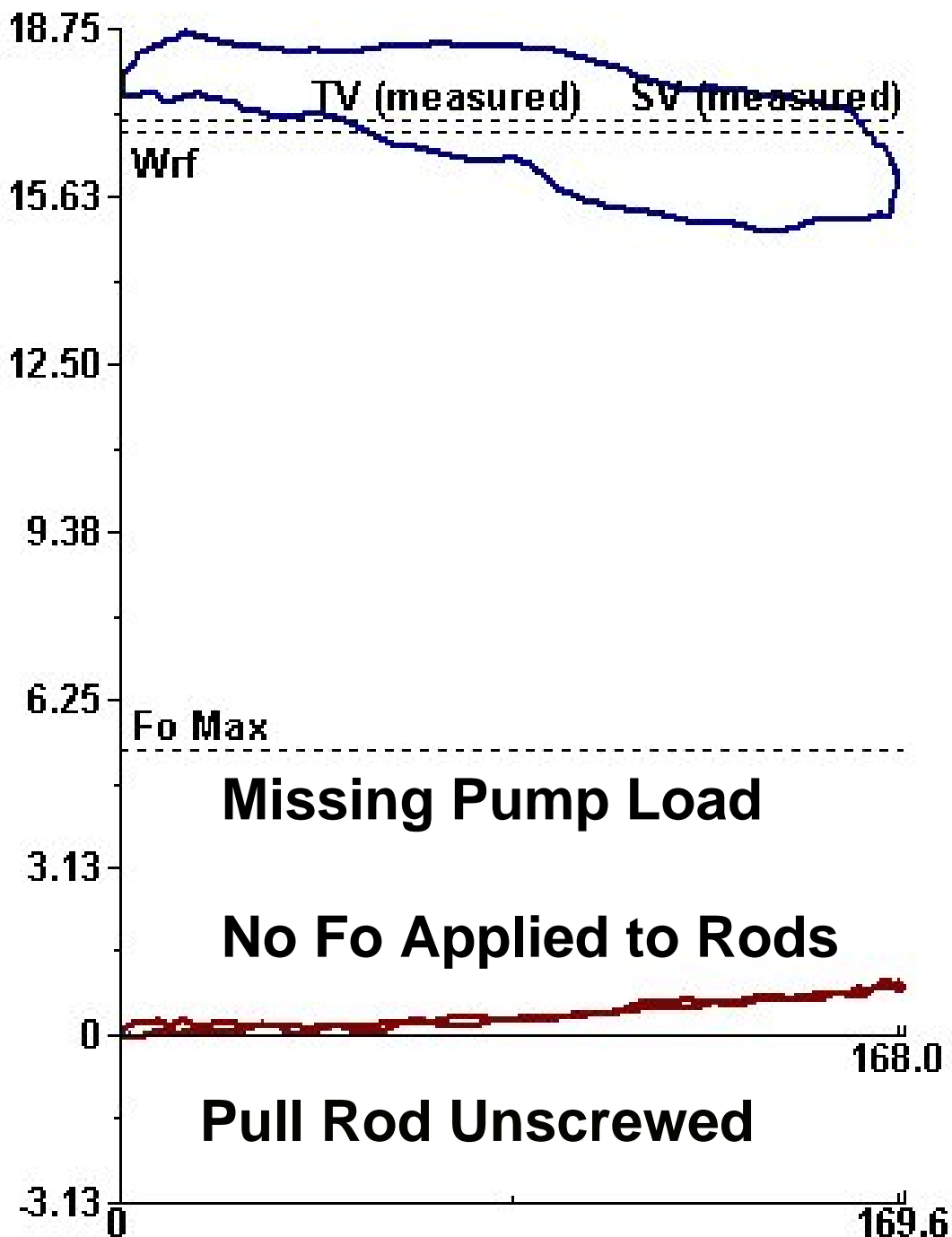


SV Sticks Open ~ TV OK?



SV Stuck Closed ~ TV OK?





Rods Parted at Pump

No fluid load from pump being applied to rod string. Parted rods are overtravel cards, because there is no loss of downhole stroke due to the static stretch of rods picking up fluid load. Measured surface dynamometer card loads are near standing valve load (Wrf).

Note that both the standing and traveling valves measured test loads are at the calculated standing valve test load.

Sometimes trash in the pump keeps the traveling valve ball from going on seat. Tagging on the down stroke before pulling, may knock out trash.

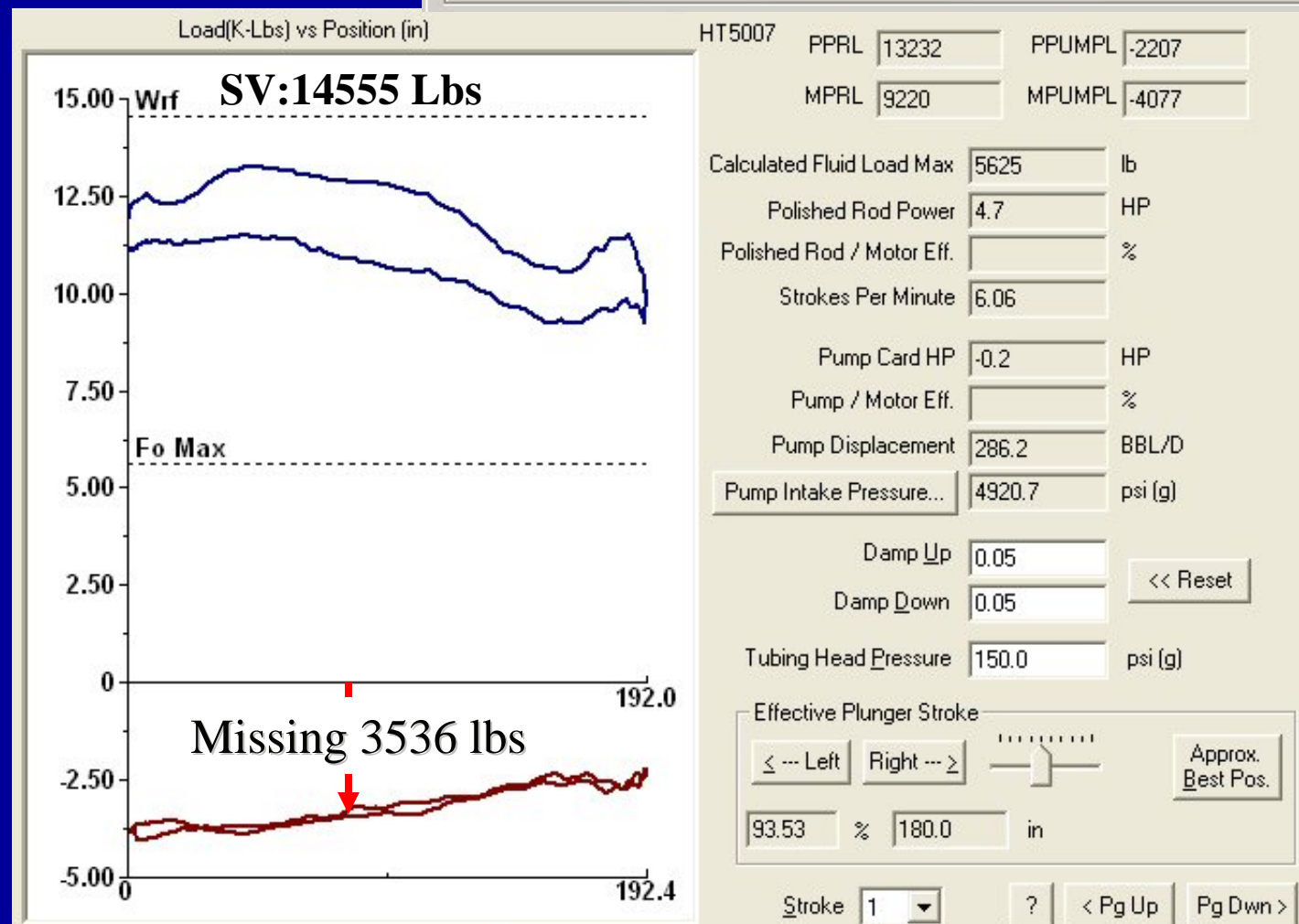
Missing 37 3/4" Rods Parted @ 5365'

Pump Card Sets Below the Zero Load Line By Weight of Missing Rods

Missing:
Wrf 3536 lbs

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[Alt-2] Rod String				
	Top Taper	Taper 2	Taper 3	Taper 4
Rod Type	D	D	D	SB
Length	1927.00	2475.00	2350.00	275.00
Diameter	1.000	0.875	0.750	1.500
Weight	5573.2	5474.6	3815.1	1795.6
Damp Up	0.05		Damp Down 0.05	



Missing 37 3/4" Rods

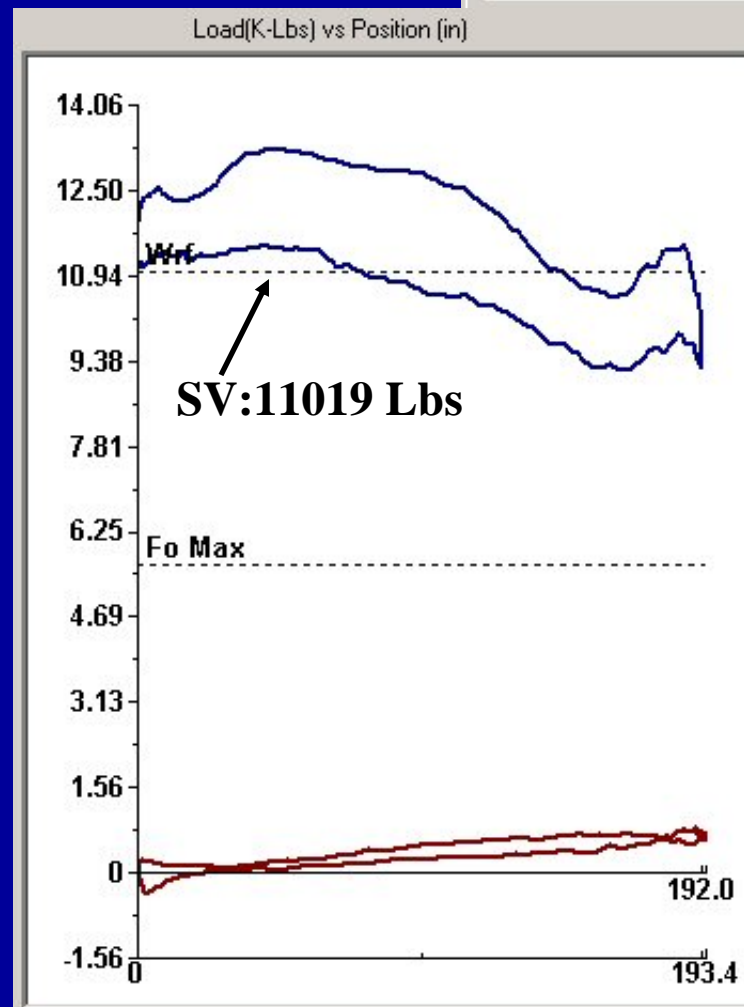
Adjusted Rod
Length, then
Pump Card
sets on Zero
Load Line

No Pump
No Fo Rods

Sept. 9 - 12, 2008

[Alt-2] Rod String

	Top Taper	Taper 2	Taper 3	Taper 4
Rod Type	D	D	D	NONE
Length	1927.00	2475.00	963.00	275.00
Diameter	1.000	0.875	0.750	1.500
Weight	5573.2	5474.6	1563.3	
Damp Up	0.05	Damp Down		0.05



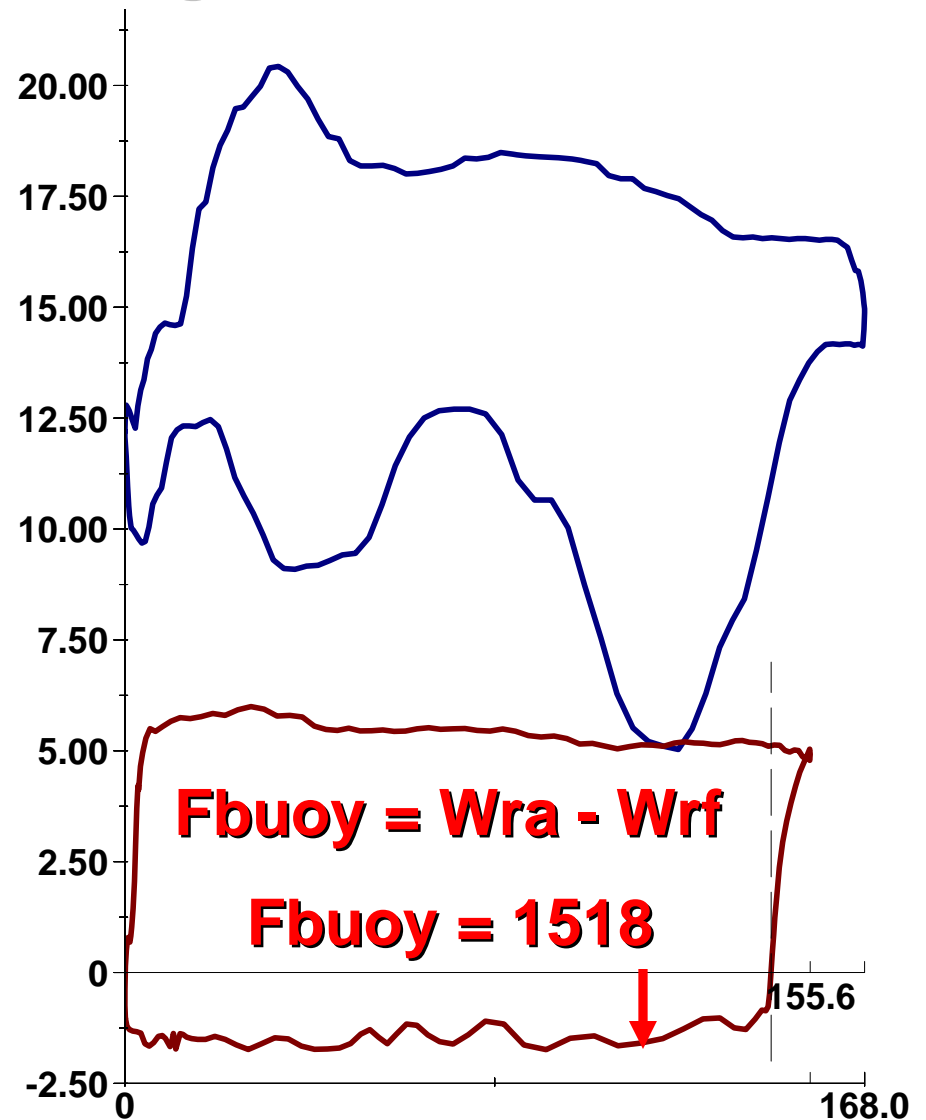
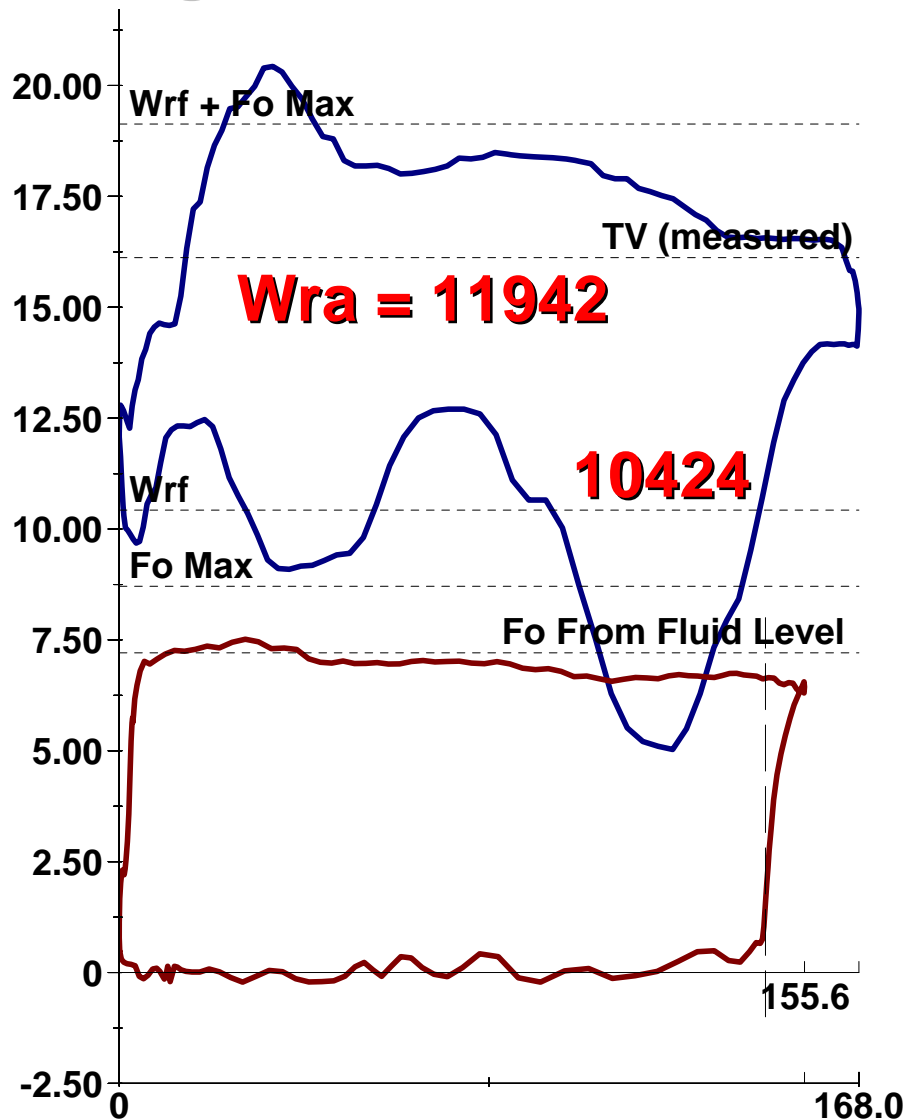
HT5007

PPRL	13232	PPUMPL	814
MPRL	9220	MPUMPL	.389
Calculated Fluid Load Max	5625	lb	
Polished Rod Power	4.7	HP	
Polished Rod / Motor Eff.		%	
Strokes Per Minute	6.06		
Pump Card HP	-0.3	HP	
Pump / Motor Eff.		%	
Pump Displacement	287.6	BBL/D	
Pump Intake Pressure...	3011.2	psi (g)	
Damp Up	0.05	<< Reset	
Damp Down	0.05		
Tubing Head Pressure	150.0	psi (g)	
Effective Plunger Stroke			
< ... Left		Right ... >	Approx. Best Pos.
93.53	%	180.9	in
Stroke	1		
		< Pg Up	Pg Dwn >

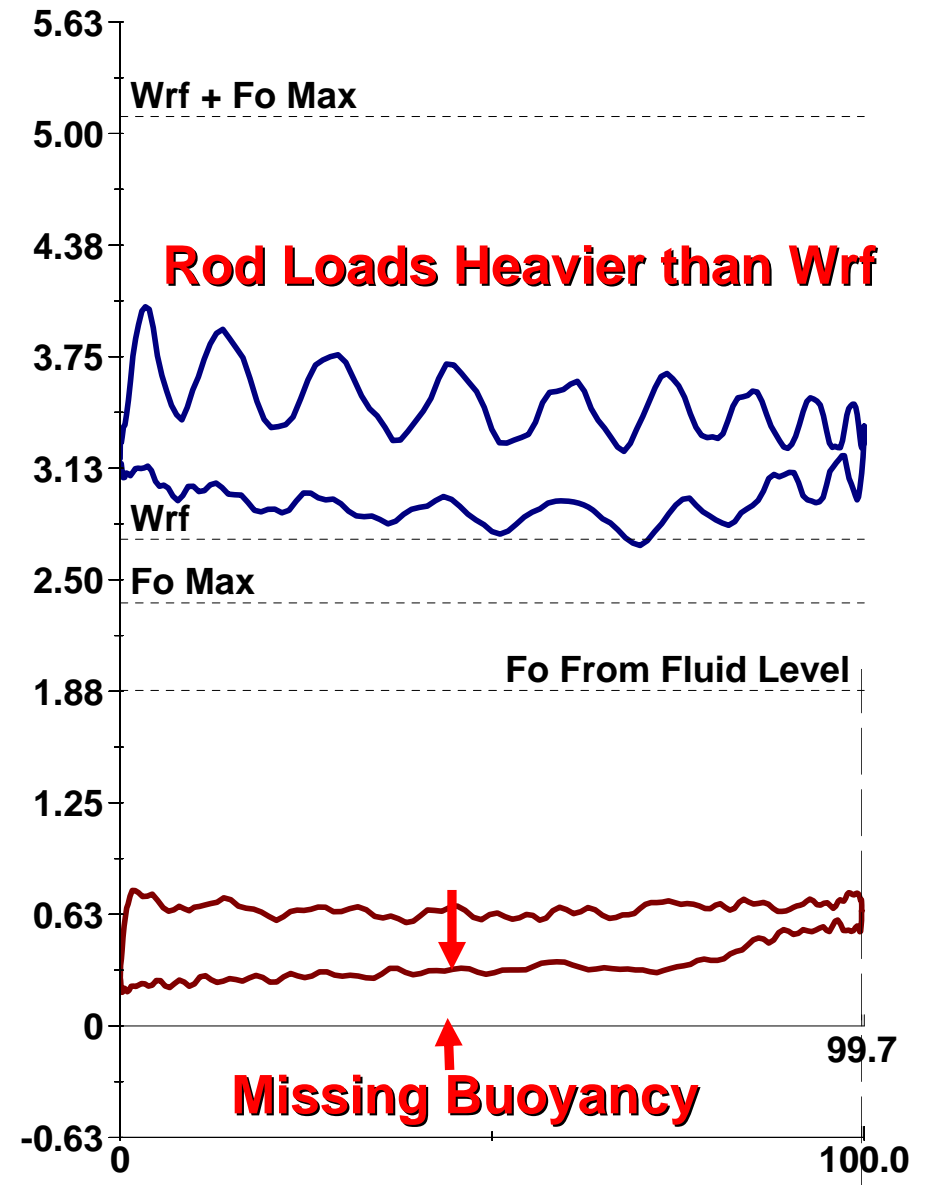
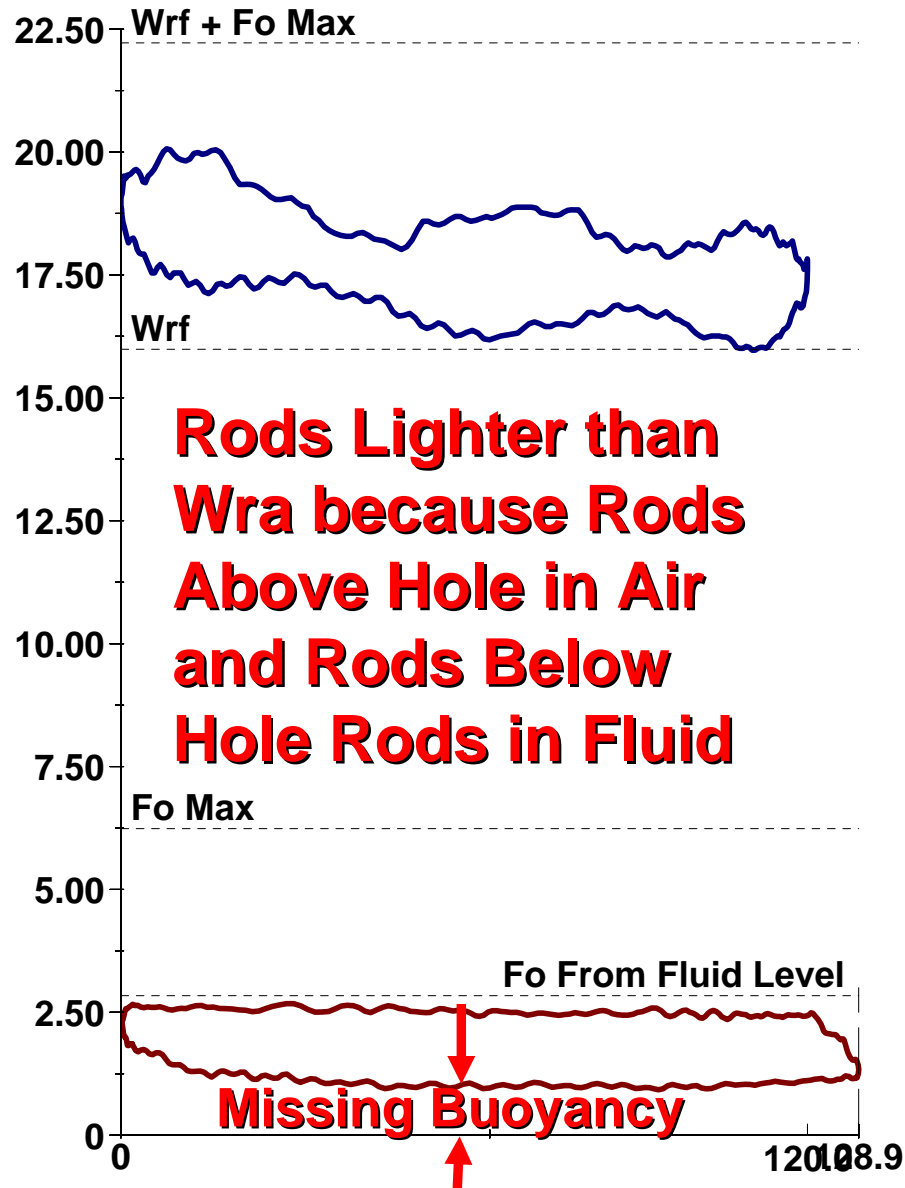
Buoyancy – Tubing Fluid Gradient

Tubing Fluid Gradient = 0.432

Tubing Fluid Gradient = 0.0



Missing Buoyancy – Hole in Tubing



Location of Pump Card with Respect to Basic Loads are Critical to Analysis

- 1) Location of Pump Load can be Used to Identify and Troubleshoot Problem in the Well.
- 2) Pump card that plots as a flat line could be:

TV Stuck Open	Tubing Dry
Deep Rod Part	SV Stuck Open
Shallow Rod Part	Blocked Intake

- 3) OK Pump Card should plot between Zero Load Line and Fo from Fluid Level Line
- 4) If Polished Rod Transducer used to acquire dynamometer data **and pump card is flat**
 - Difficult to identify problem
 - All of the loads plot on the zero load line.

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