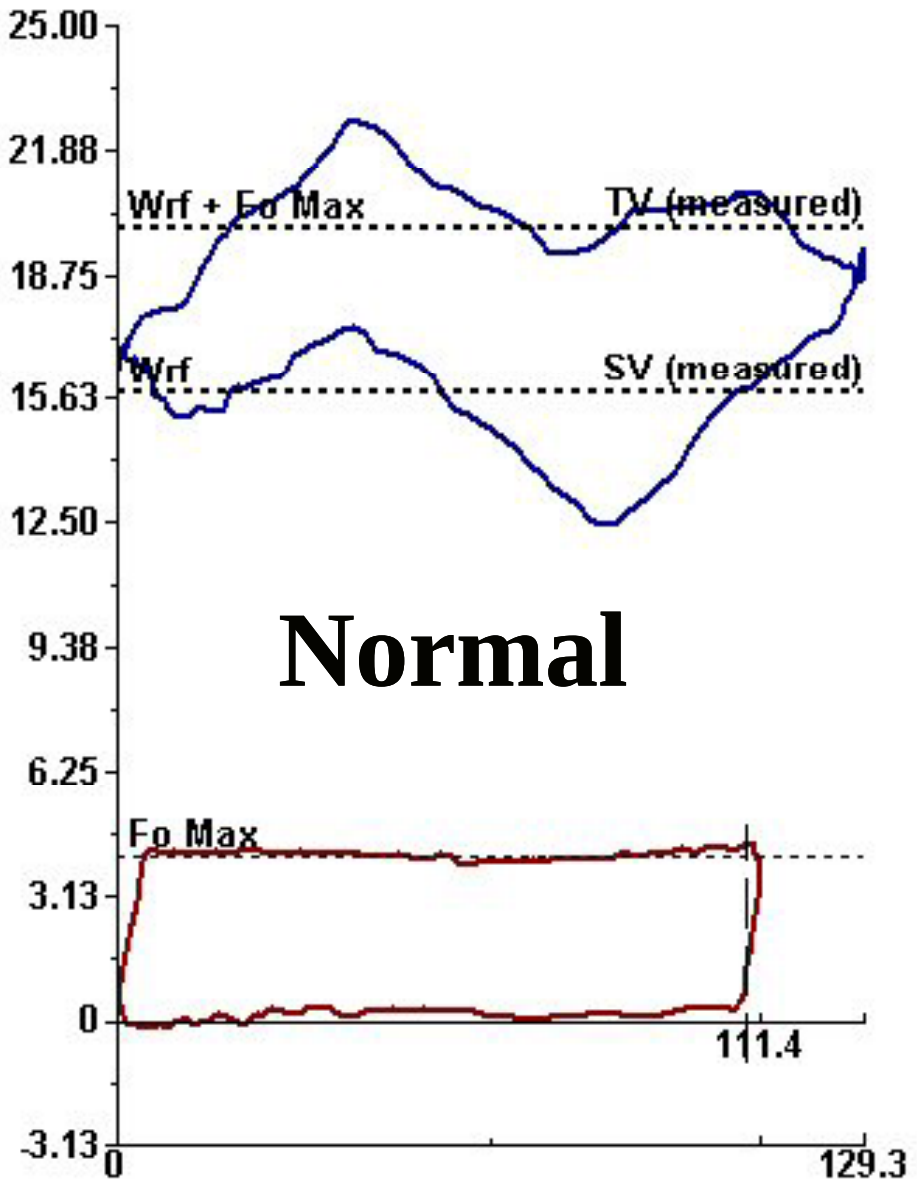
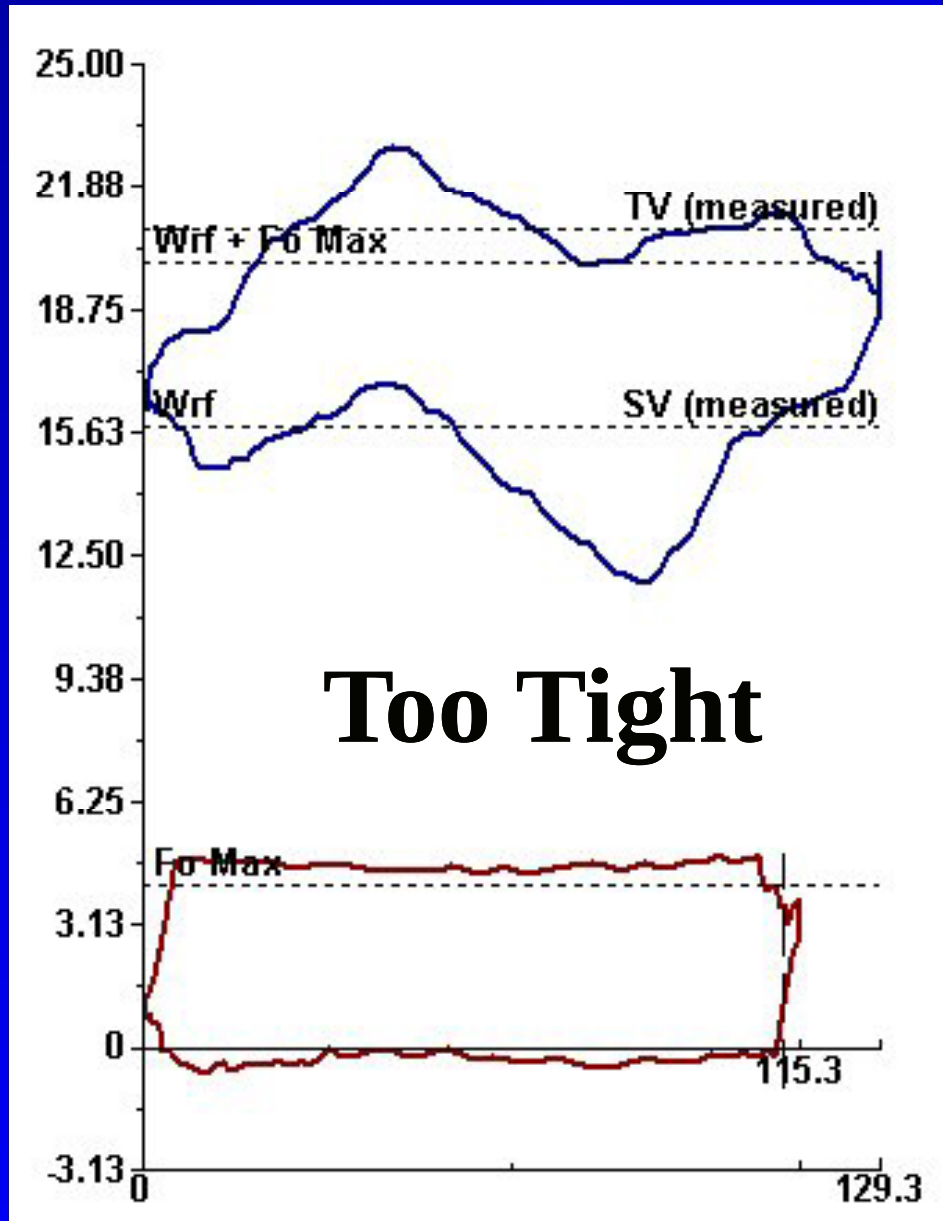
Artificial Lift Analyst Function:

1. Goal is to answer the WELL PERFORMANCE QUESTIONS
2. Time Requirement is about 45 minutes per well.
3. Analyze collected data at the well.
4. Make recommendations to fix any problems discovered.
5. Record work necessary to fix problem as notes in the comments text box.
6. When recommended changes completed, new data should be collected once the well stabilized
7. Notice if well performance changed as planned.
8. Follow-up on recommendations to learn from successes and failures
9. Role changes from a data collector to a knowledgeable well analyst and problem solver.

Abnormal Loads – Tight Stuffing Box

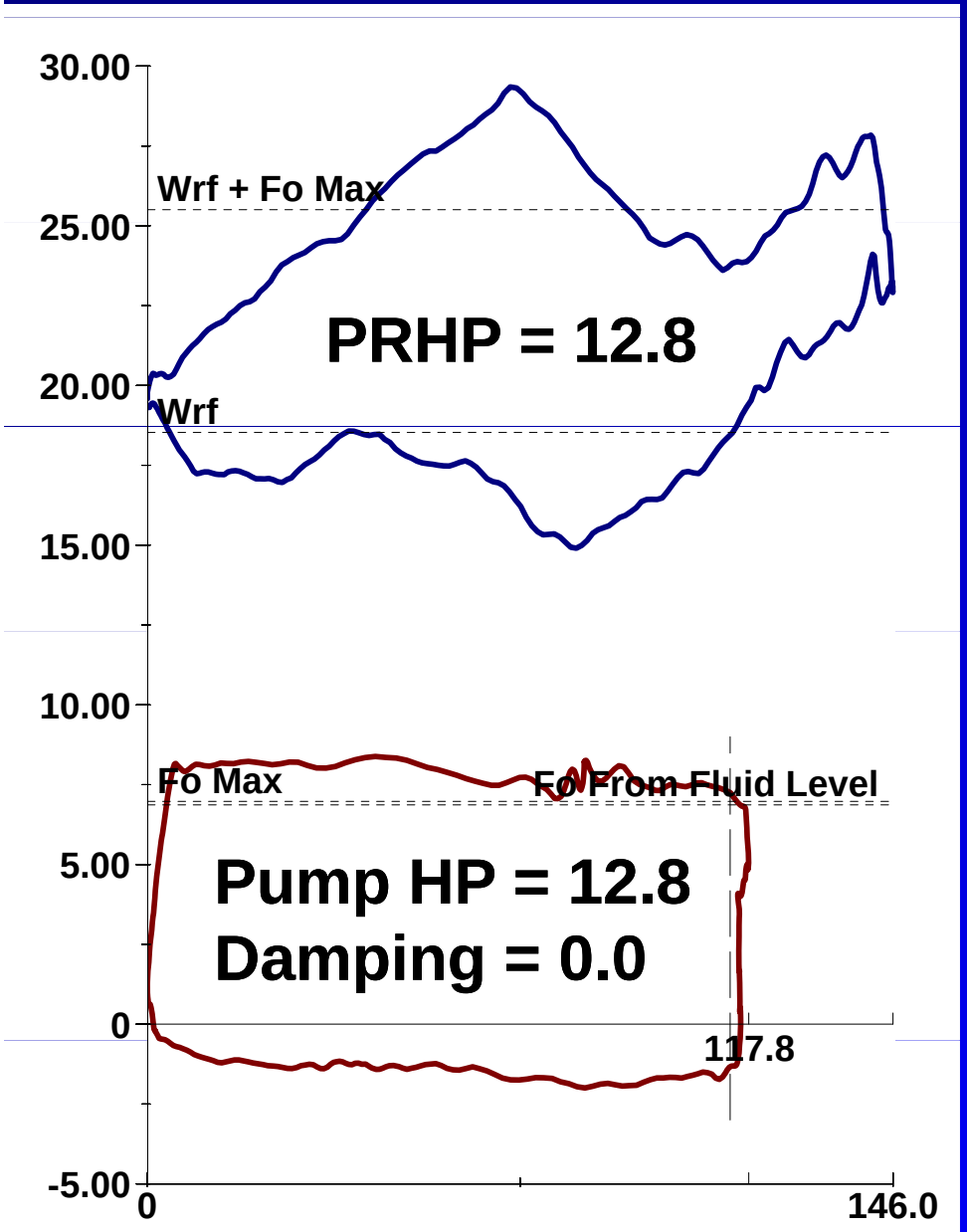


Normal



Too Tight

Damping for Pump Set in Horizontal

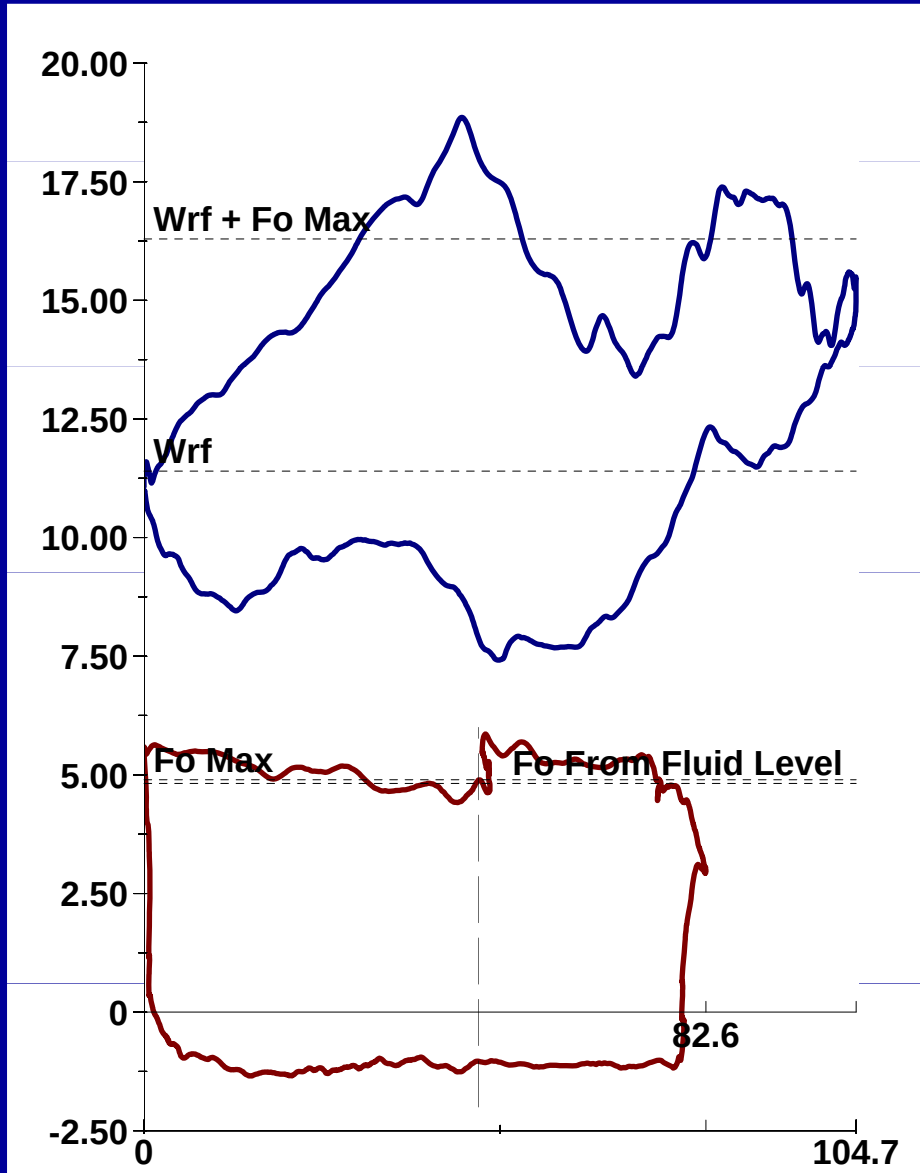


1. Polish Rod HP Minus Damping Equals Pump HP.

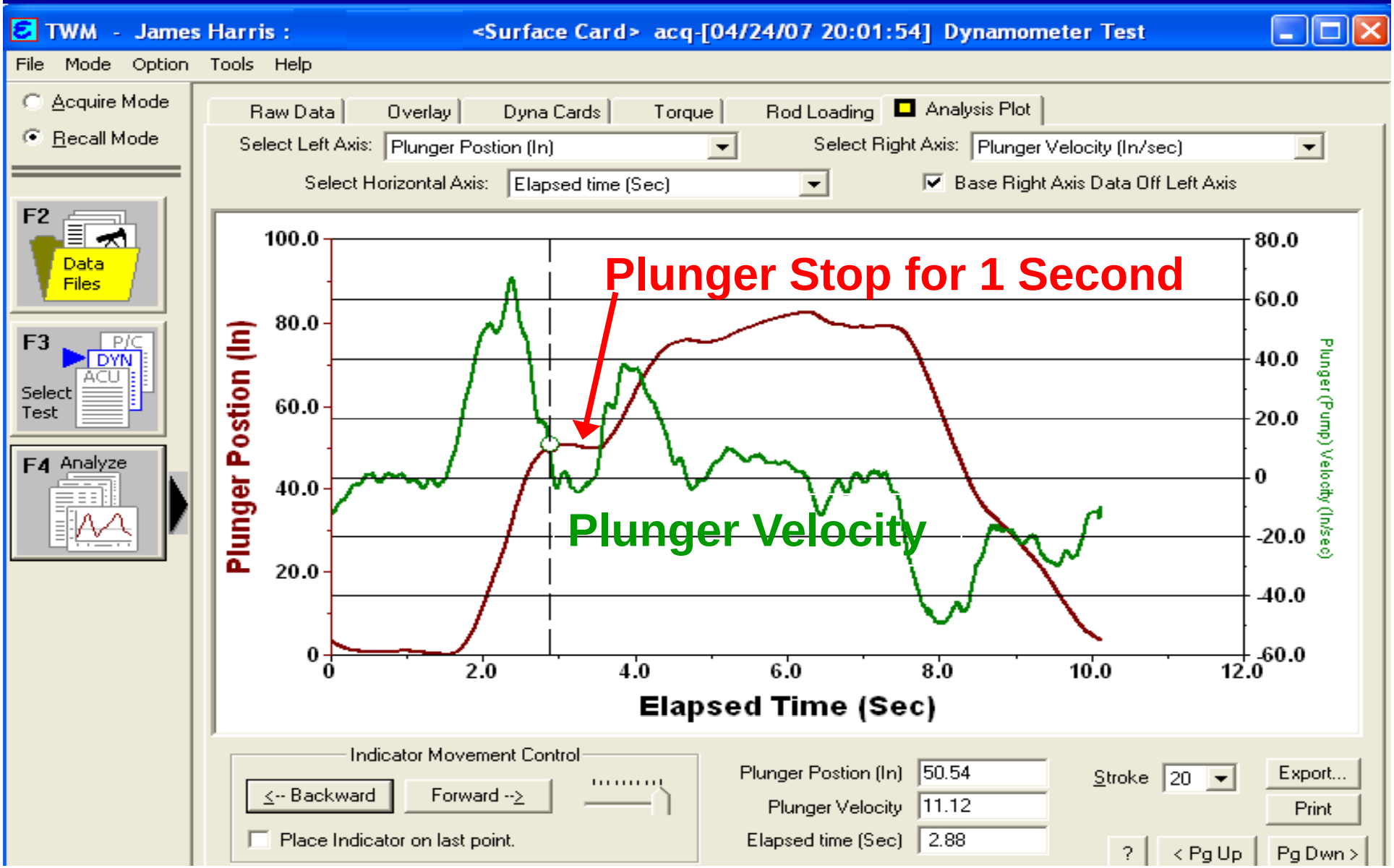
2. Polish Rod Horsepower less frictional horsepower equals the hydraulic horsepower, and represents work being done at the pump.

Dynamometer Cards

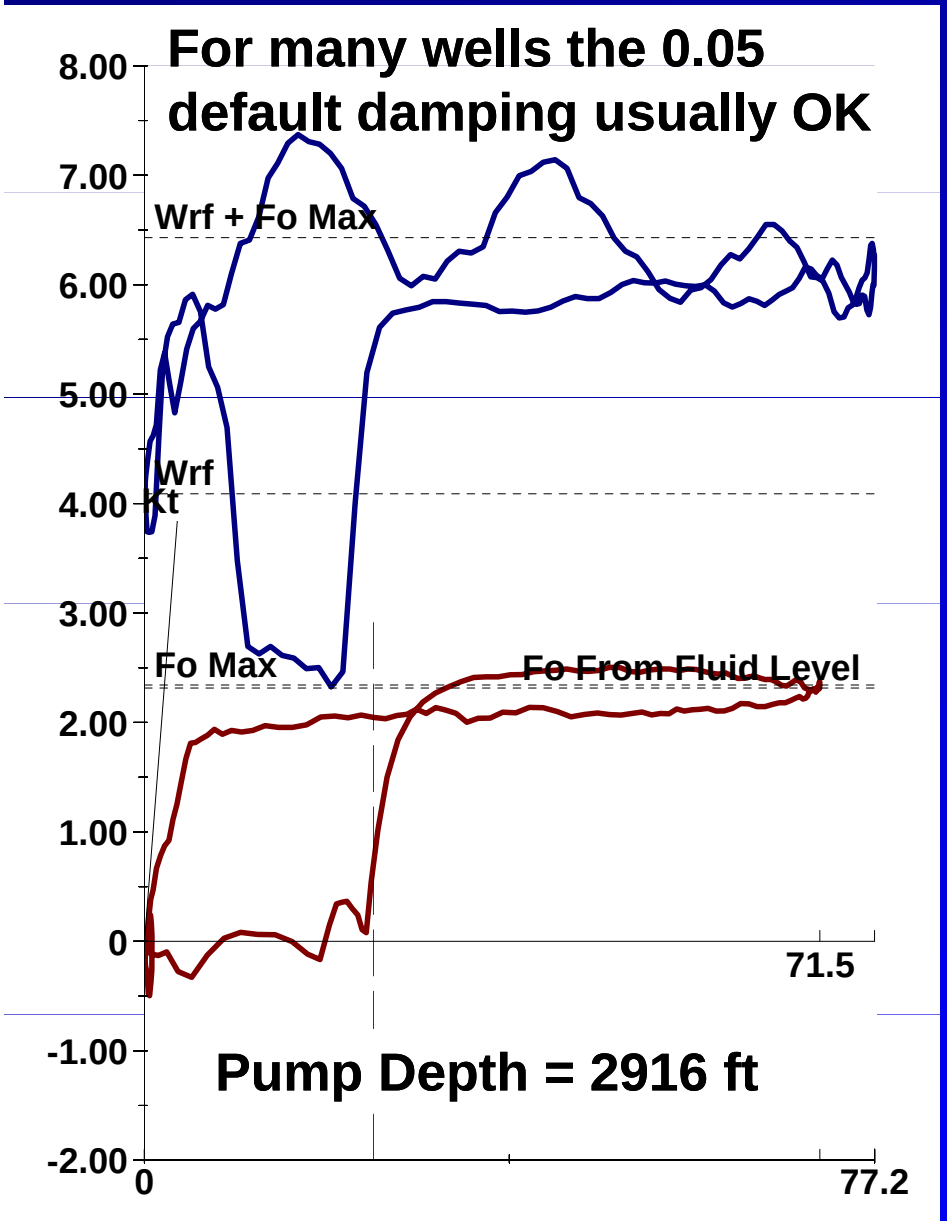
1) Diagnostic dynamometer surface cards used for Diagnosing Sucker Rod Pumping Systems.
2) Pump dynamometer card is to identify and analyze downhole problems.
3) Spike load at 49.5 inches on Stroke #20 shows when the plunger stopped on the upstroke. Unusual shape occurs over a 1 second time period and represents 1850 lb load increase required to overcome the downhole friction.

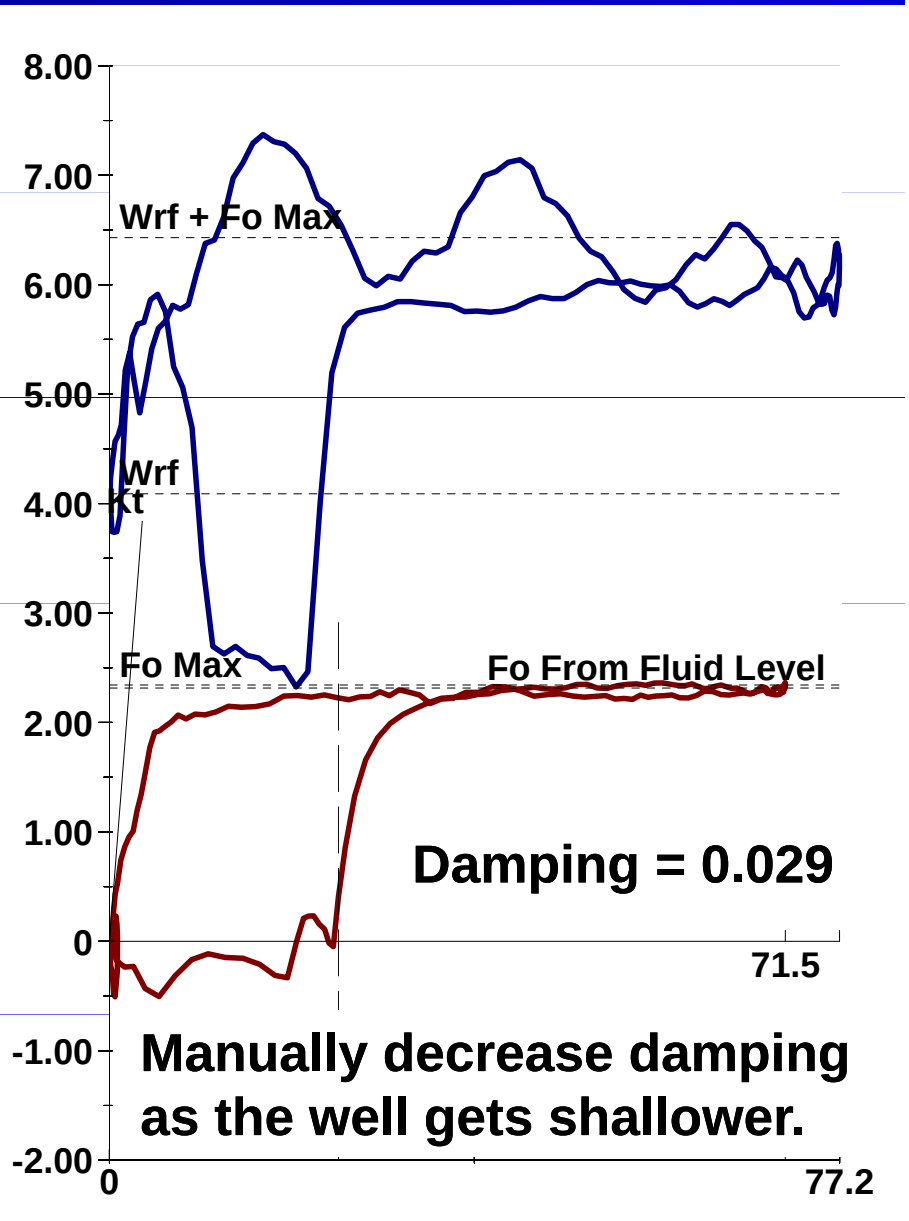


15 inches of Surface Stroke (73-88 inches on Upstroke) Lost to Rod Stretch in-order to apply Force to overcome Sudden 1850 lbs of Unknown Friction on Rods and Plunger

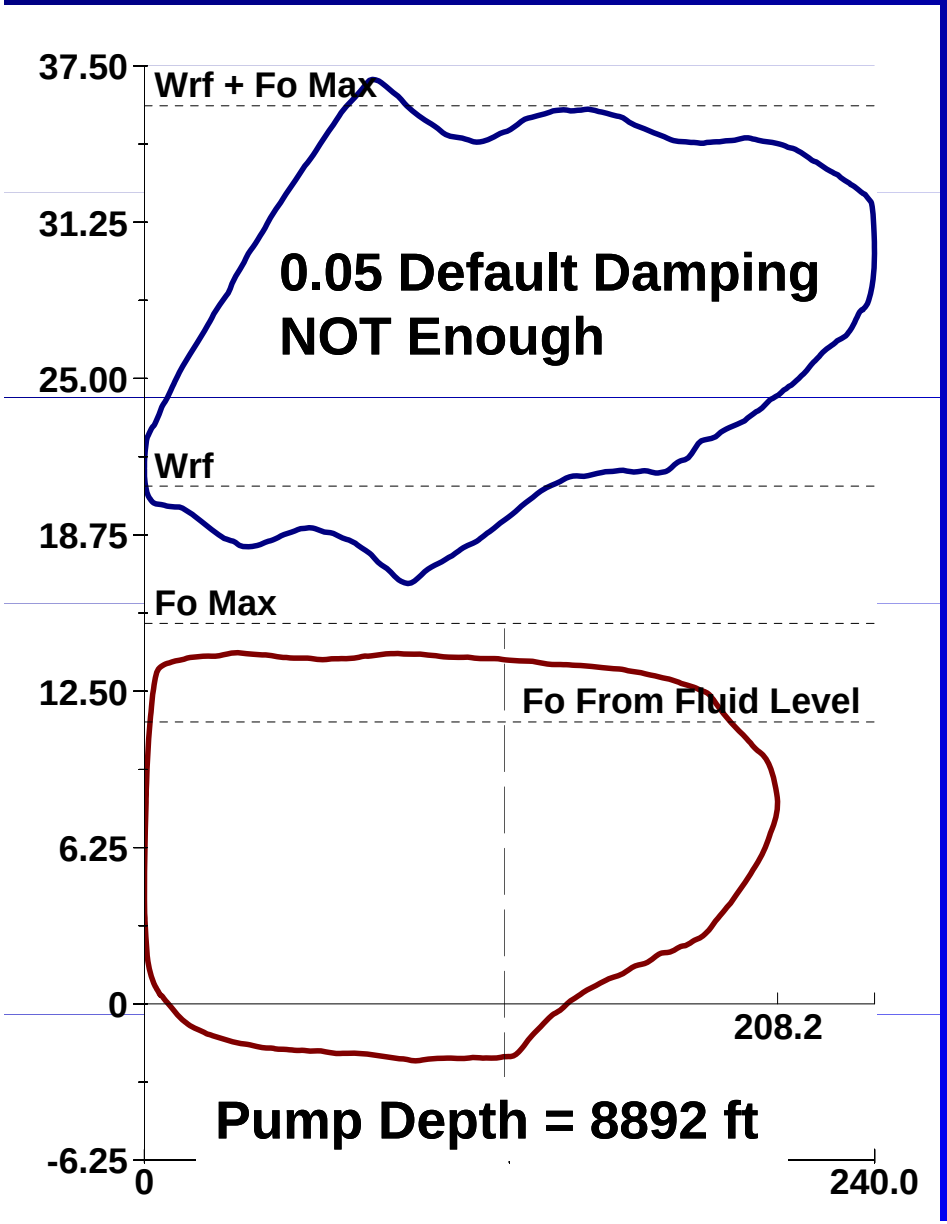


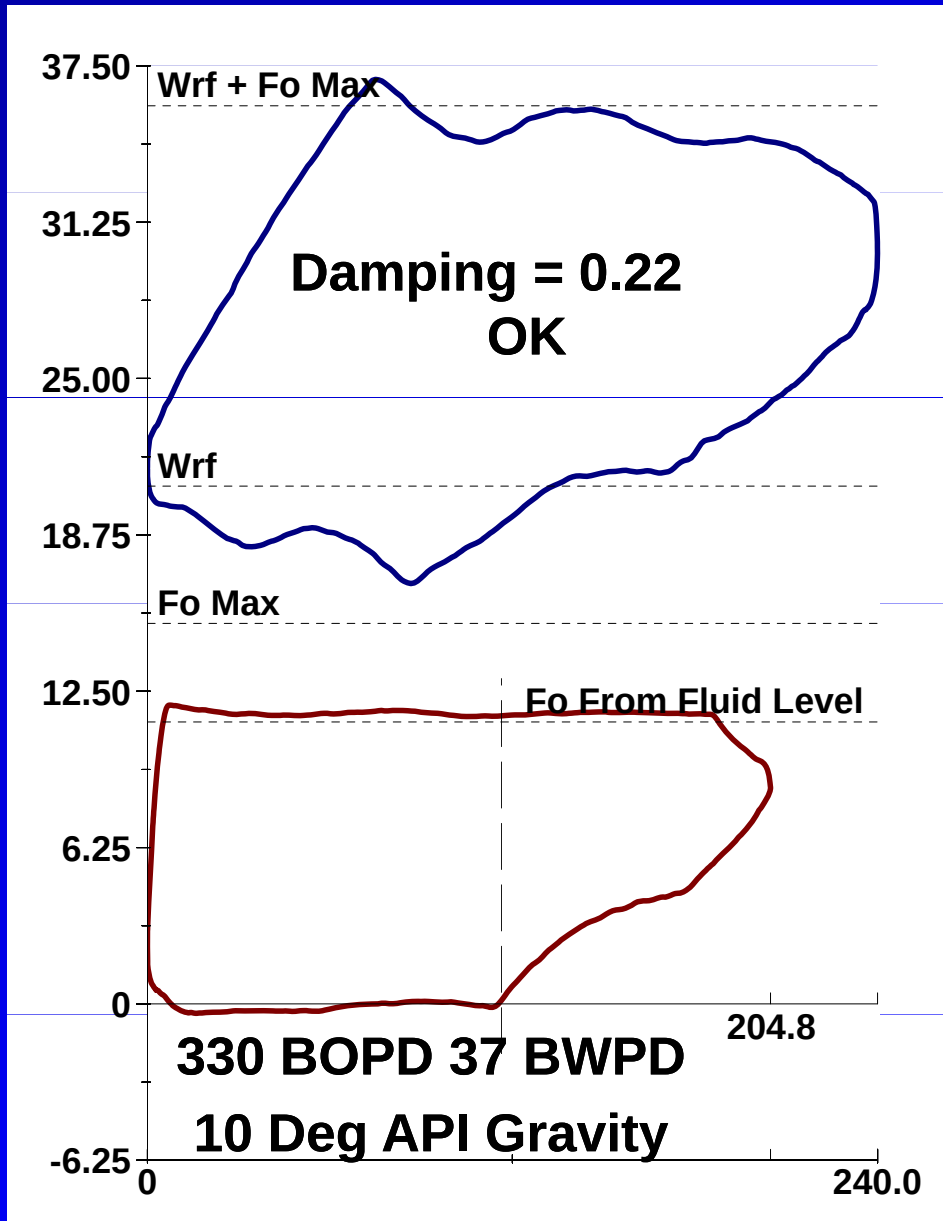
Damping Coefficients for Shallow Wells are usually 0.01/1000 foot of Pump Depth

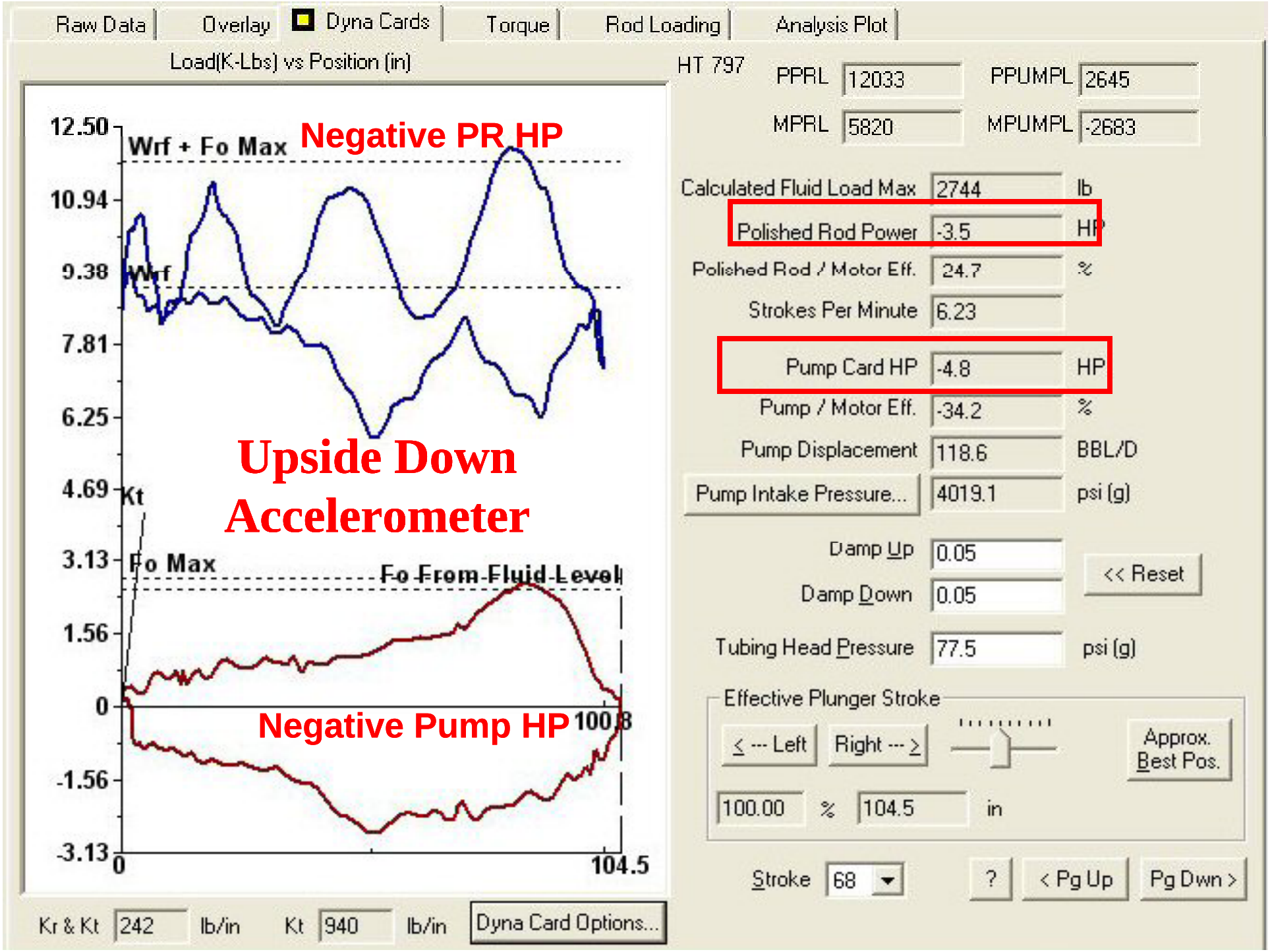




Damping Coefficients for Viscous Crude

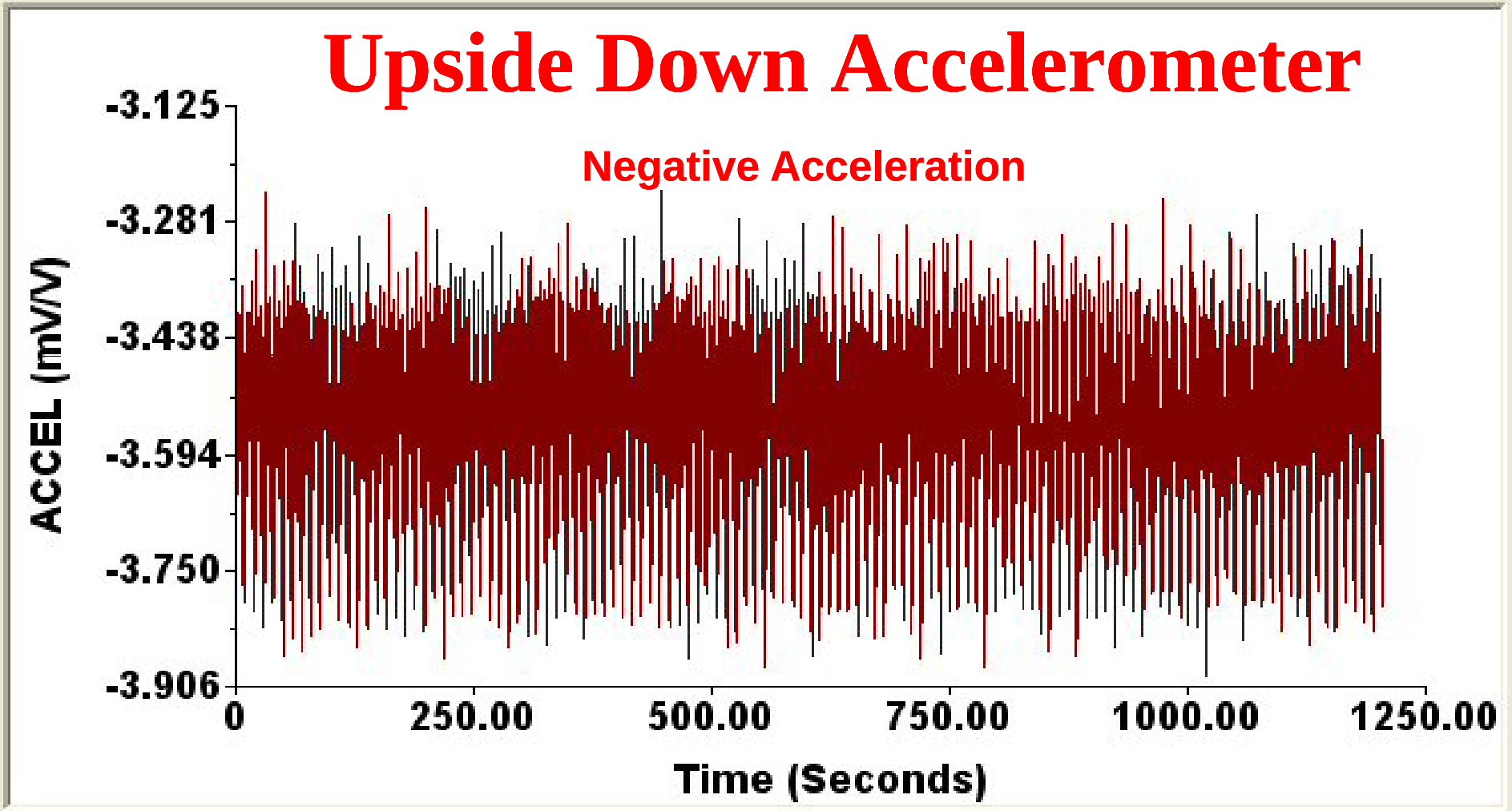





Raw Data
Overlay
Dyna Cards
Torque
Rod Loading
Analysis Plot
Load(K-Lbs) vs Position (in)
12.50
10.94
9.38
7.81
6.25
4.69
3.13
1.56
0
-1.56
-3.13
Wrf + Fo Max
Negative PR HP
Wrf
Kt
Fo Max
Fo From Fluid Level
Upside Down
Accelerometer
Negative Pump HP
0
104.5
HT 797
PPRL 12033
PPUMPL 2645
MPRL 5820
MPUMPL -2683
Calculated Fluid Load Max 2744 lb
Polished Rod Power -3.5 HP
Polished Rod / Motor Eff. 24.7 %
Strokes Per Minute 6.23
Pump Card HP -4.8 HP
Pump / Motor Eff. -34.2 %
Pump Displacement 118.6 BBL/D
Pump Intake Pressure... 4019.1 psi (g)
Damp Up 0.05
Damp Down 0.05
<< Reset
Tubing Head Pressure 77.5 psi (g)
Effective Plunger Stroke
< --- Left
Right --- >
Approx. Best Pos.
100.00 % 104.5 in
Stroke 68
?
< Pg Up
Pg Dwn >
Kr & Kt 242 lb/in
Kt 940 lb/in
Dyna Card Options...

Raw Data | Overlay | Dyna Cards | Torque | Rod Loading | Analysis Plot

Select Graph: Acceleration



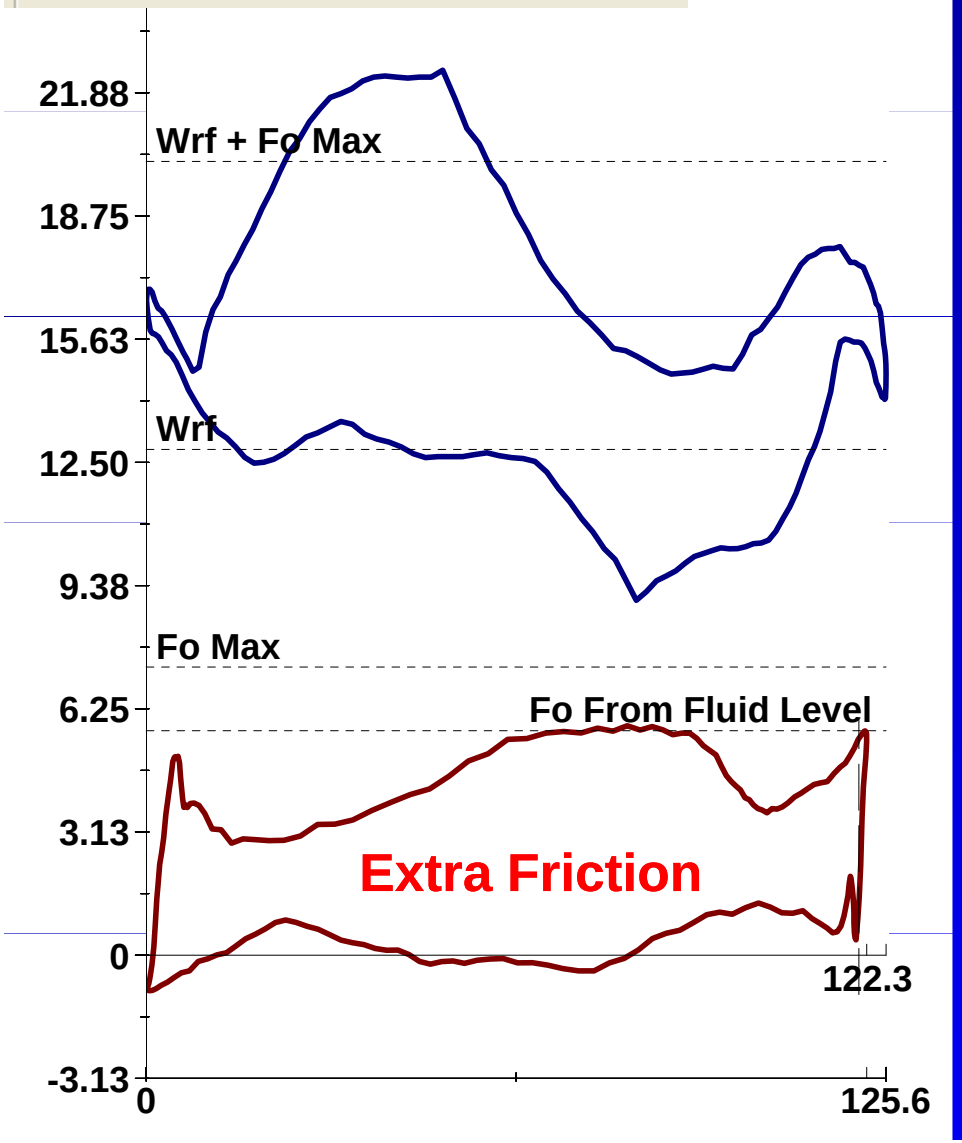
Show data in Engineering Units (e.g., lbs, in, etc...)

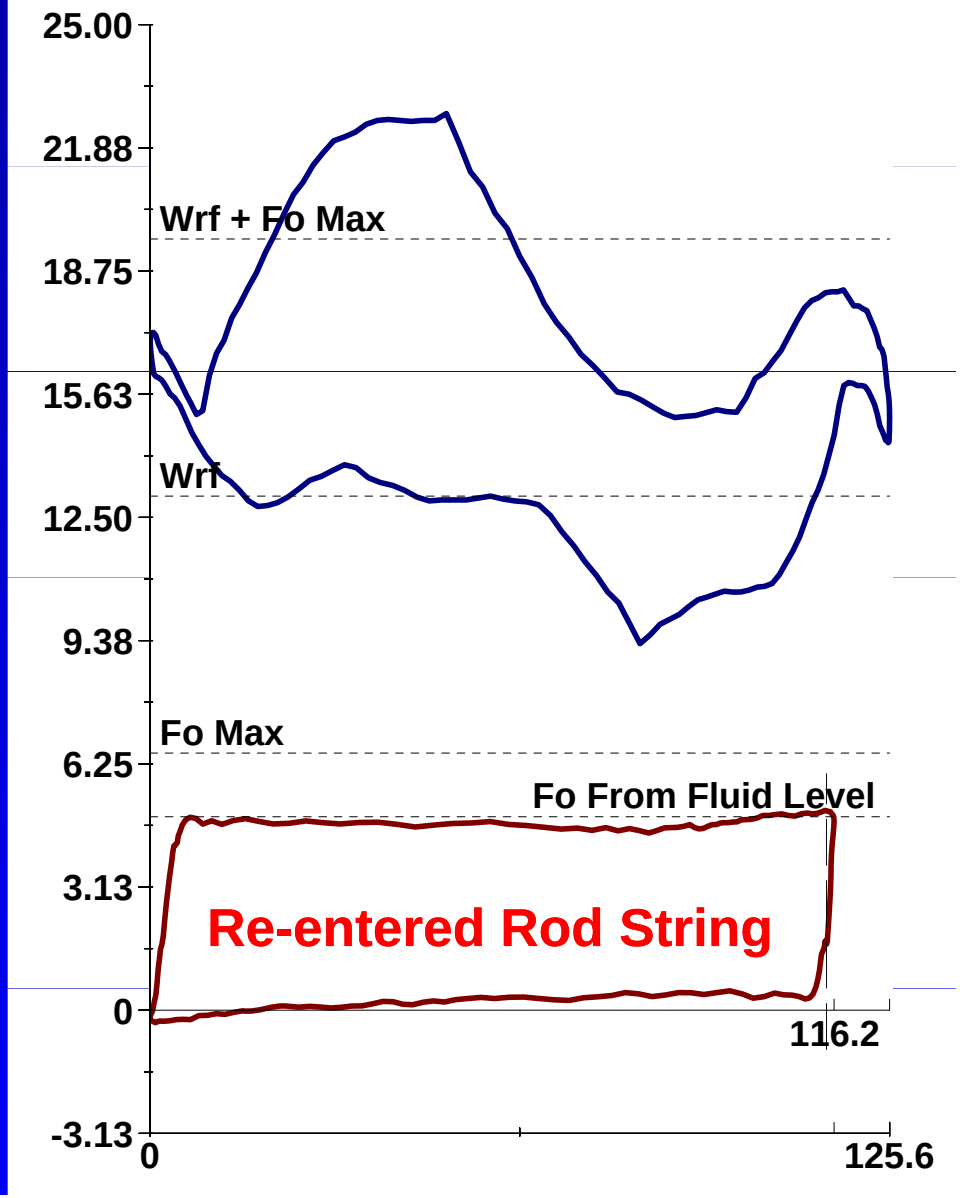
? | < Pg Up | Pg Dwn >

Need to Change Damping?

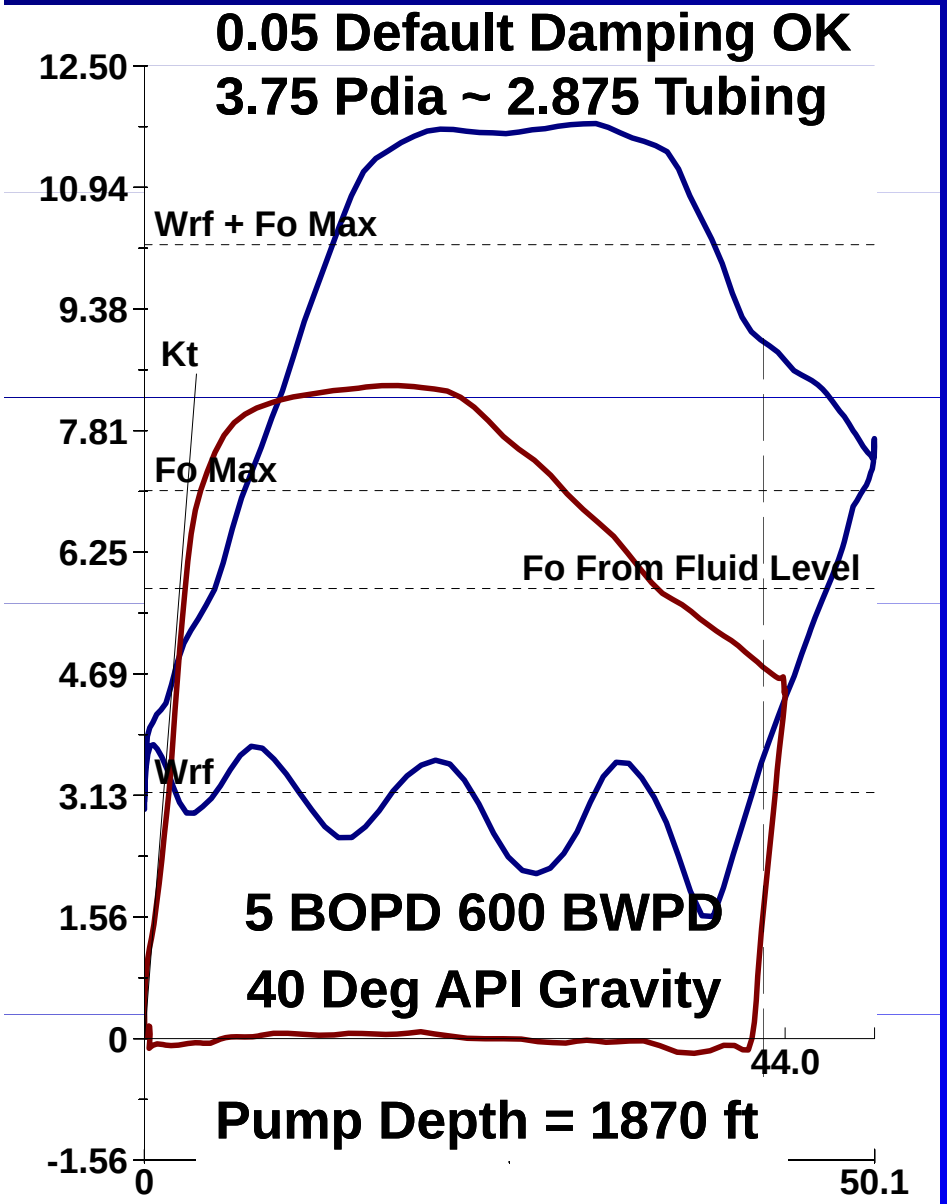
[Alt-2] Rod String

	Top Taper	Taper 2	Taper 3
Rod Type	D	D	KD
Length	2275.00	2200.00	2150.00
Diameter	0.750	0.875	1.000
Weight	3693.3	4866.4	6218.2





Damping Coefficients for Bottled up Pump



1. Pump card should fall below the FoMax line and rest on the Zero load line.
2. Restricted Discharge Area Resist Flow of Fluid out of the Pump (for example if the plunger area is greater than the area between the tubing and rods, then the pump must apply extra pressure to the fluid above the required discharge pressure)
3. Extra pressure inside pump barrel results in additional fluid load on the rods from the plunger; then the pump card Fo line can go above FoMax.

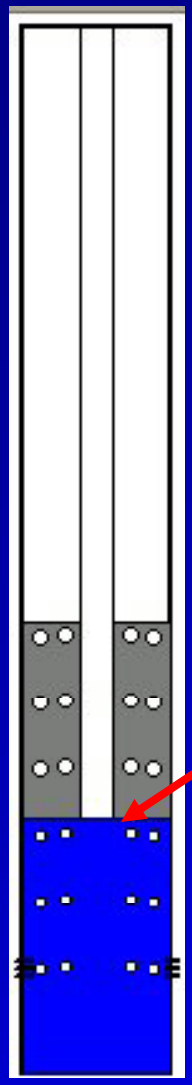
Damping Coefficients Impact PIP

1. Fo can be calculated, where Fo = (Pdis - Pintk) * Ap, is the differential pressure acting on the cross-sectional area of the plunger [Ap]. Rod string picks up the fluid load acting on the traveling valve, plunger. The differential pressure, (Pdis - Pintk), is difference between the discharge pressure, [Pdis], and the intake pressure, [Pintk].

2. Solving for pump intake pressure: (PIP = Tubing Pressure + Pump Depth(TVD)*Fluid Gradient - Fo/ Plunger Area) If you substitute in for Fo and set Pintk to zero, then you calculate FoMax.

3. Pump intake pressure calculated from the Dynamometer card is usually less than the pump intake pressure determined from a fluid level. That is because the Fo, the height of the pump card is too high (not enough damping) and the (Pdis - Pintk) calculated is too high.

Unaccounted Wellbore Friction



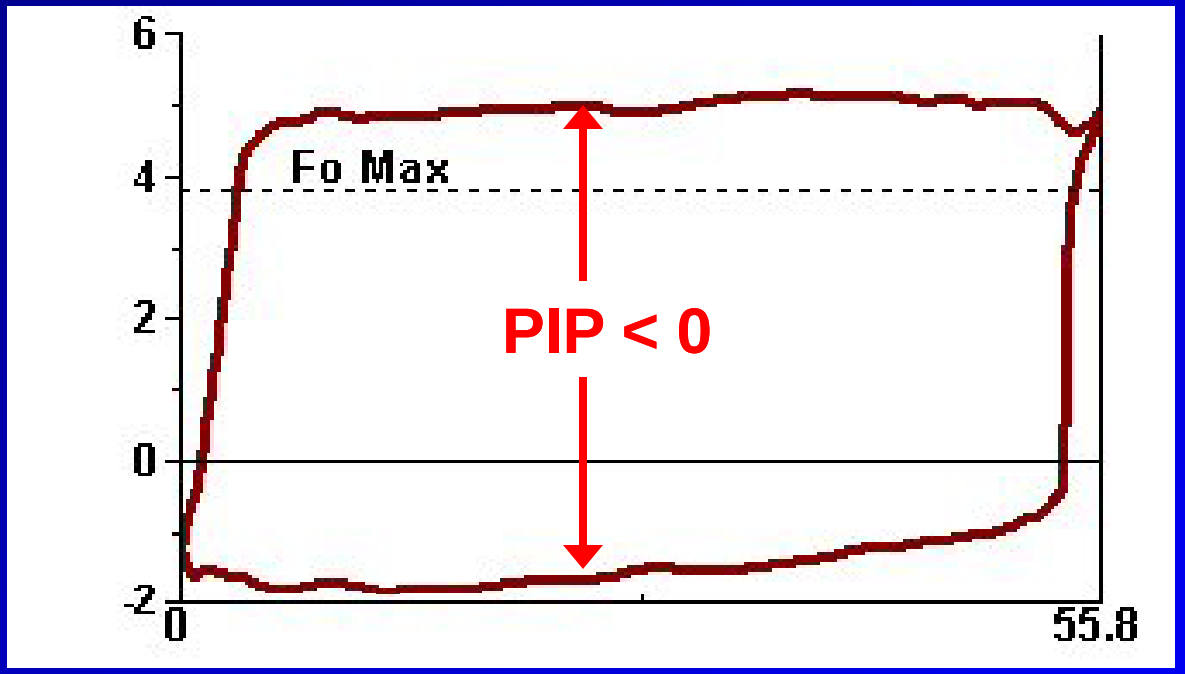
Fo(fl) = 3505

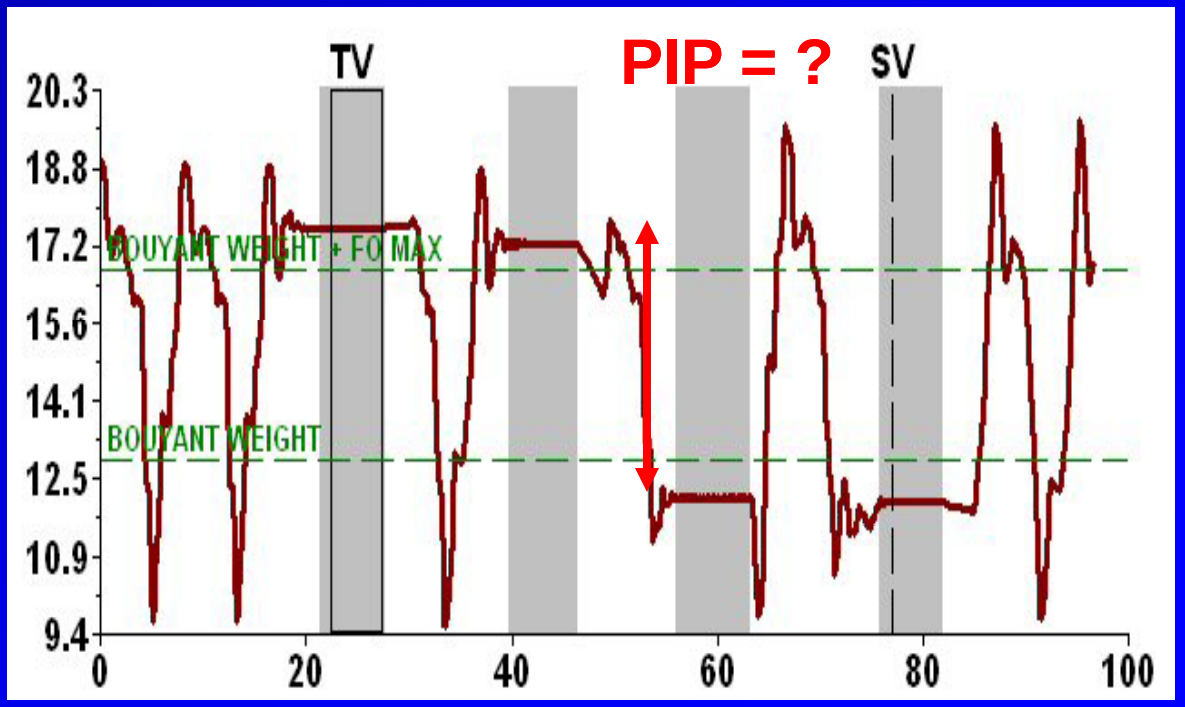
Fo(pc) = 3502

Fo(vc) = 5518

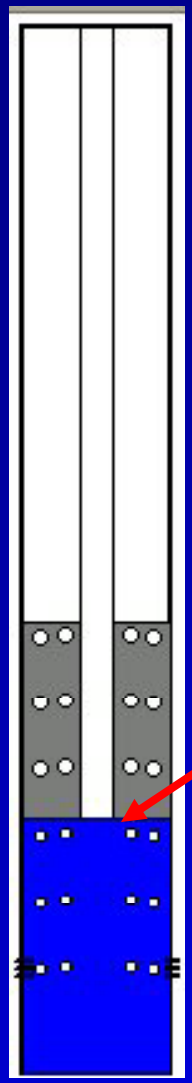
% Liq = 27

PIP = 268





Unaccounted Wellbore Friction



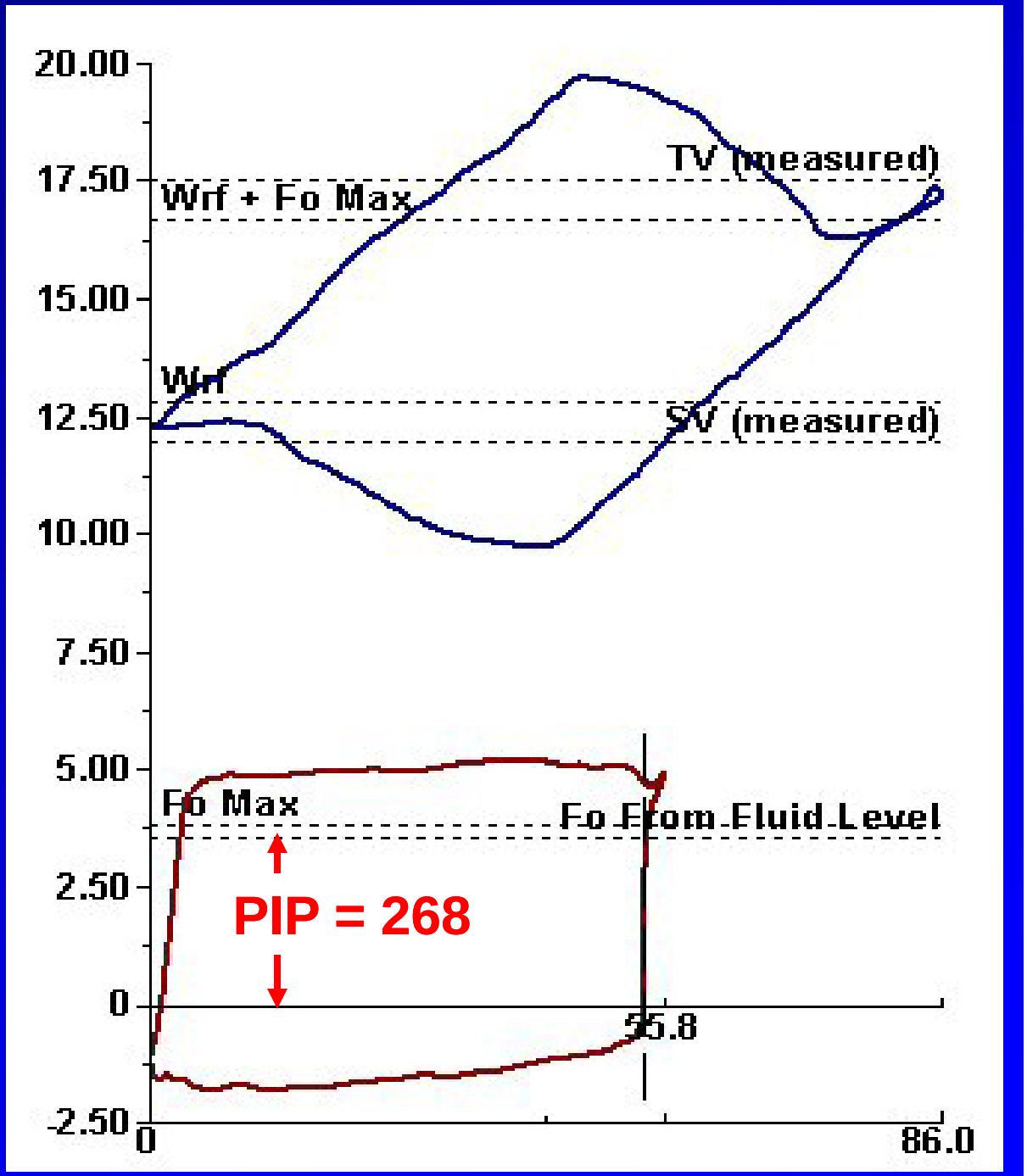
Fo(fl) = 3505

Fo(pc) = 3502

Fo(vc) = 5518

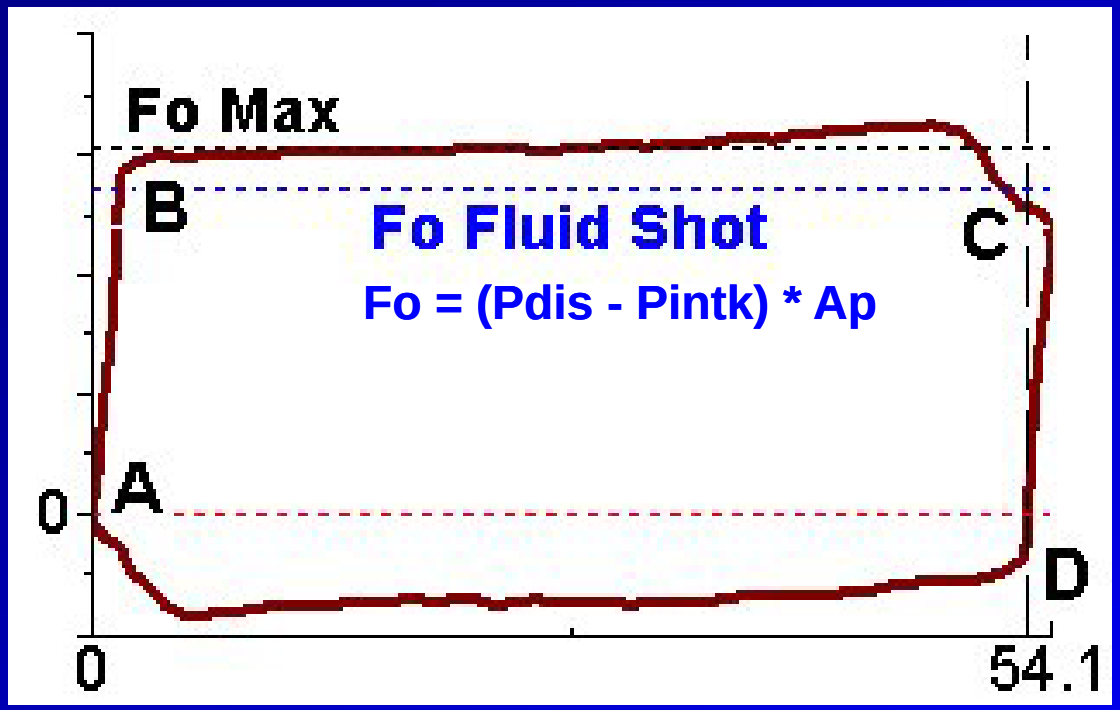
% Liq = 27

PIP = 268



Excess Well Bore Friction:

Unaccounted Friction shows up in Pump Card

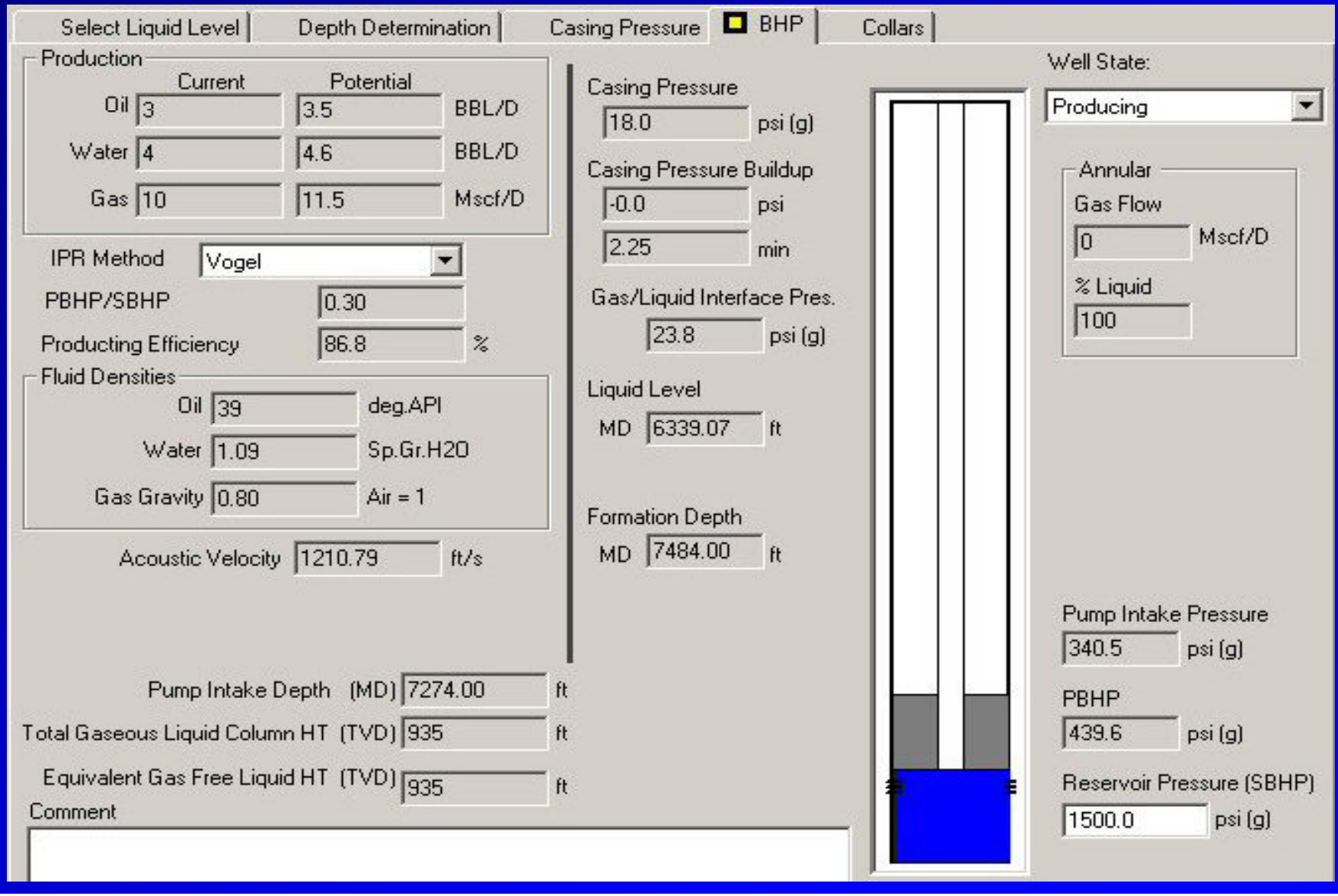


Possible Sources:

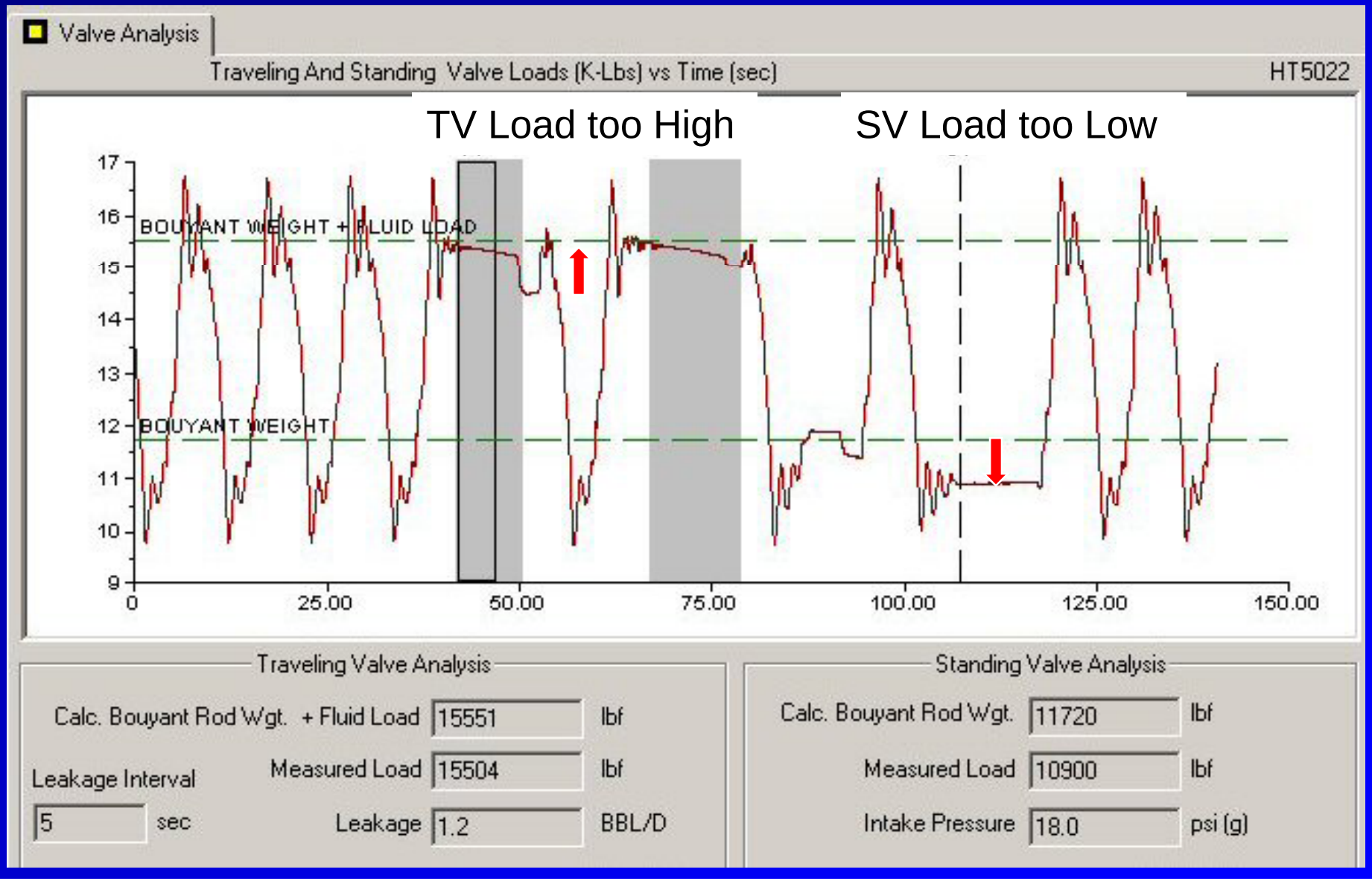
1. Paraffin
2. Scale
3. Over Tight Stuffing Box
4. Misalignment
5. Deviated Well
6. Pump Friction
7. Crimped Tubing
8. Other

Pump card has calculated loads much higher than the Fluid Load based on a shot Fluid Level. Pump card normally should set between the ZERO load line & Fo Max, pump loads outside this range indicate friction unaccounted for by wave equation.

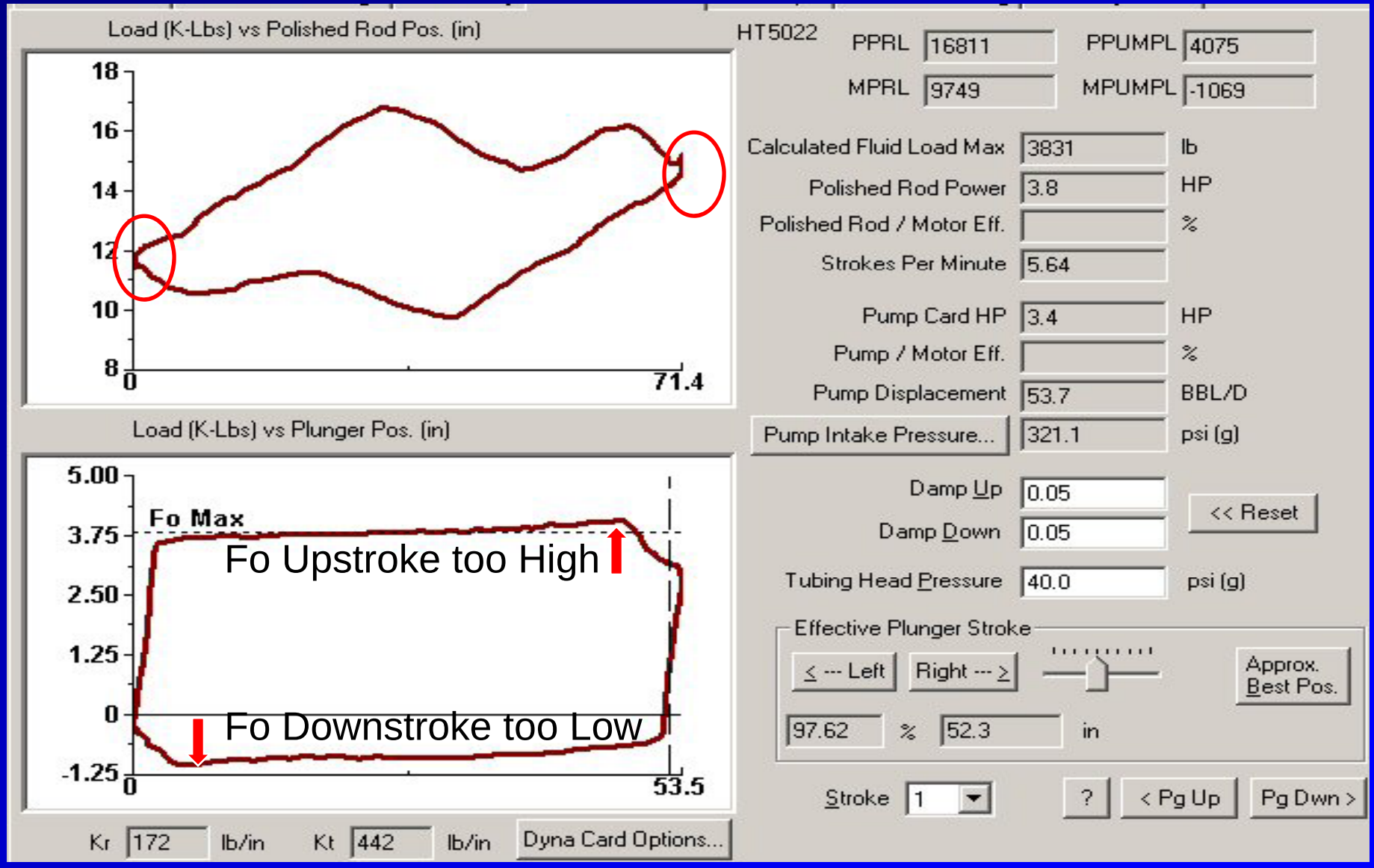
Excess Well Bore Friction: Reduced Downhole Stroke & Raised Fluid Level



Excess Well Bore Friction: Friction Affects Valve Load Test



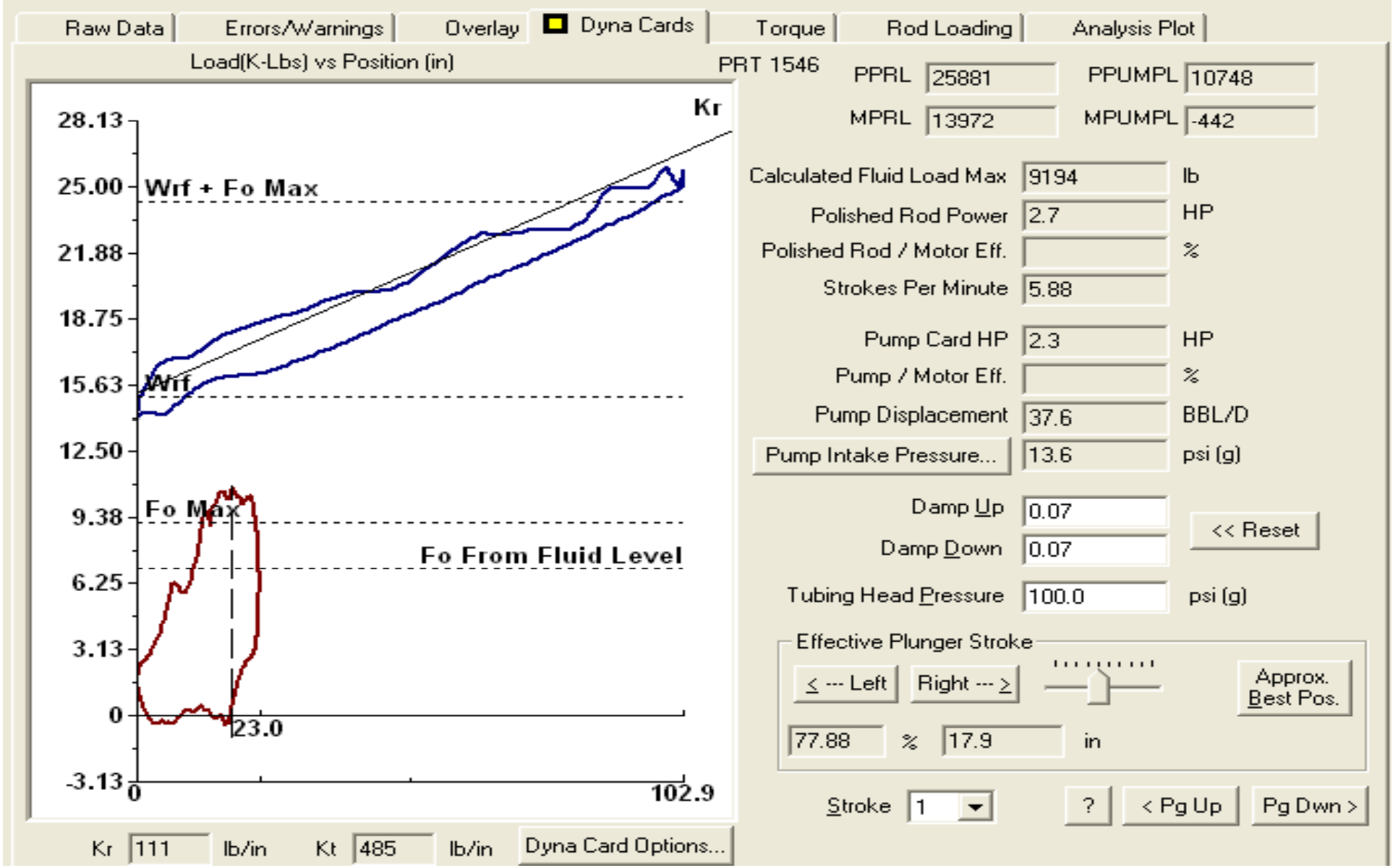
Excess Well Bore Friction: Friction Affects Dyno Cards



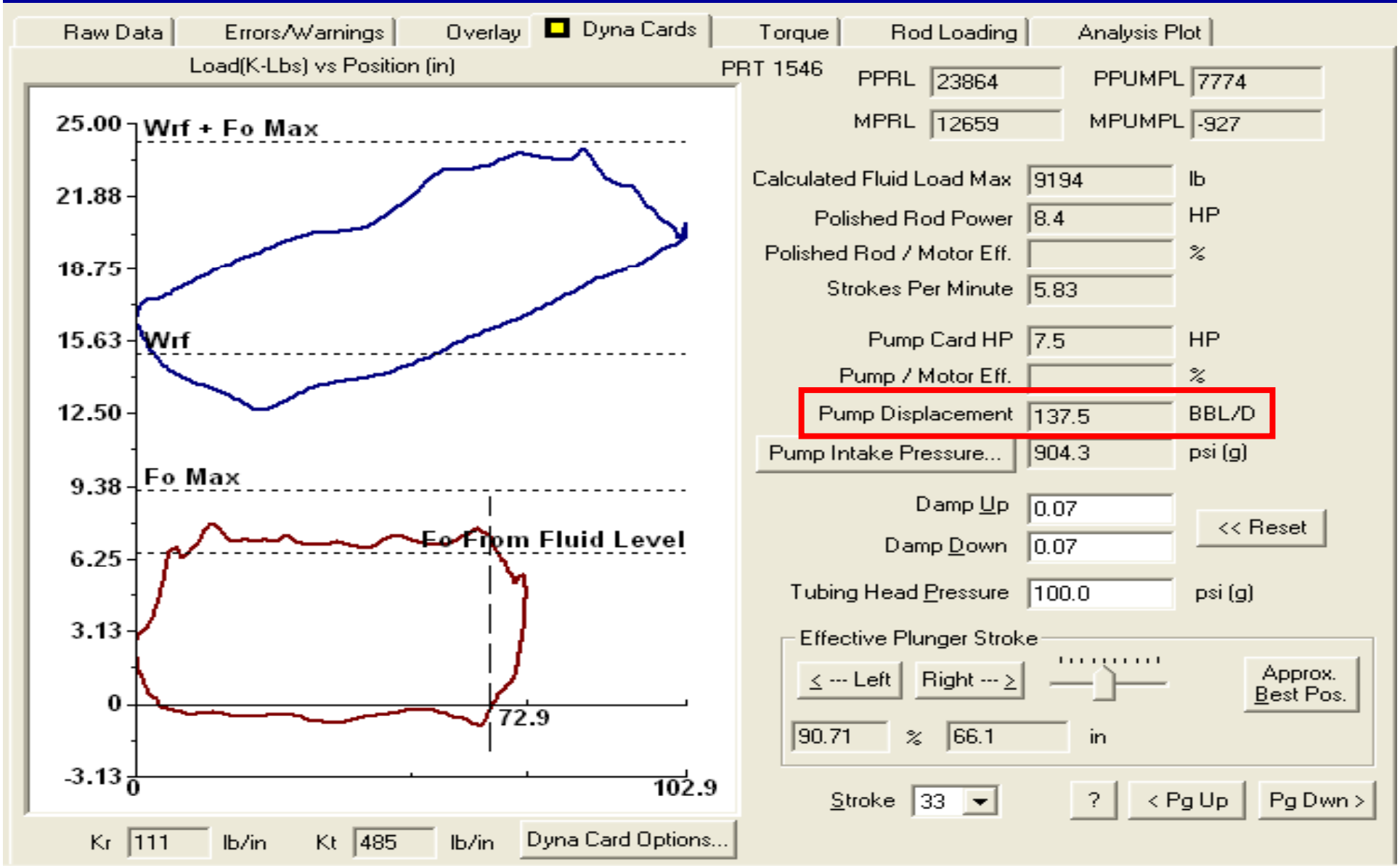
Excess Well Bore Friction Indicators

1) Fluid Level is higher than normal
2) Surface card shows a vertical change in load at the top and bottom of the stroke (Extra friction opposite to the direction of movement is broken by changing the direction of motion of the rod string)
3) Pump card should set between the ZERO load line & Fo Max, pump loads outside this range indicate of unaccounted friction.
4) SV valve check is low and TV check is too high (Friction is resisting the lifting the rods on the upstroke and friction is holding rod load on the downstroke)
5) TV load immediately drops as brake released (When the direction of motion changes or the rods go from stopped to moving the friction force that was being applied opposite to the prior motion of the rods is broken).
6) Low system efficiency

Investigation of Well Problem:
83% of Surface Stroke lost to Rod Stretch

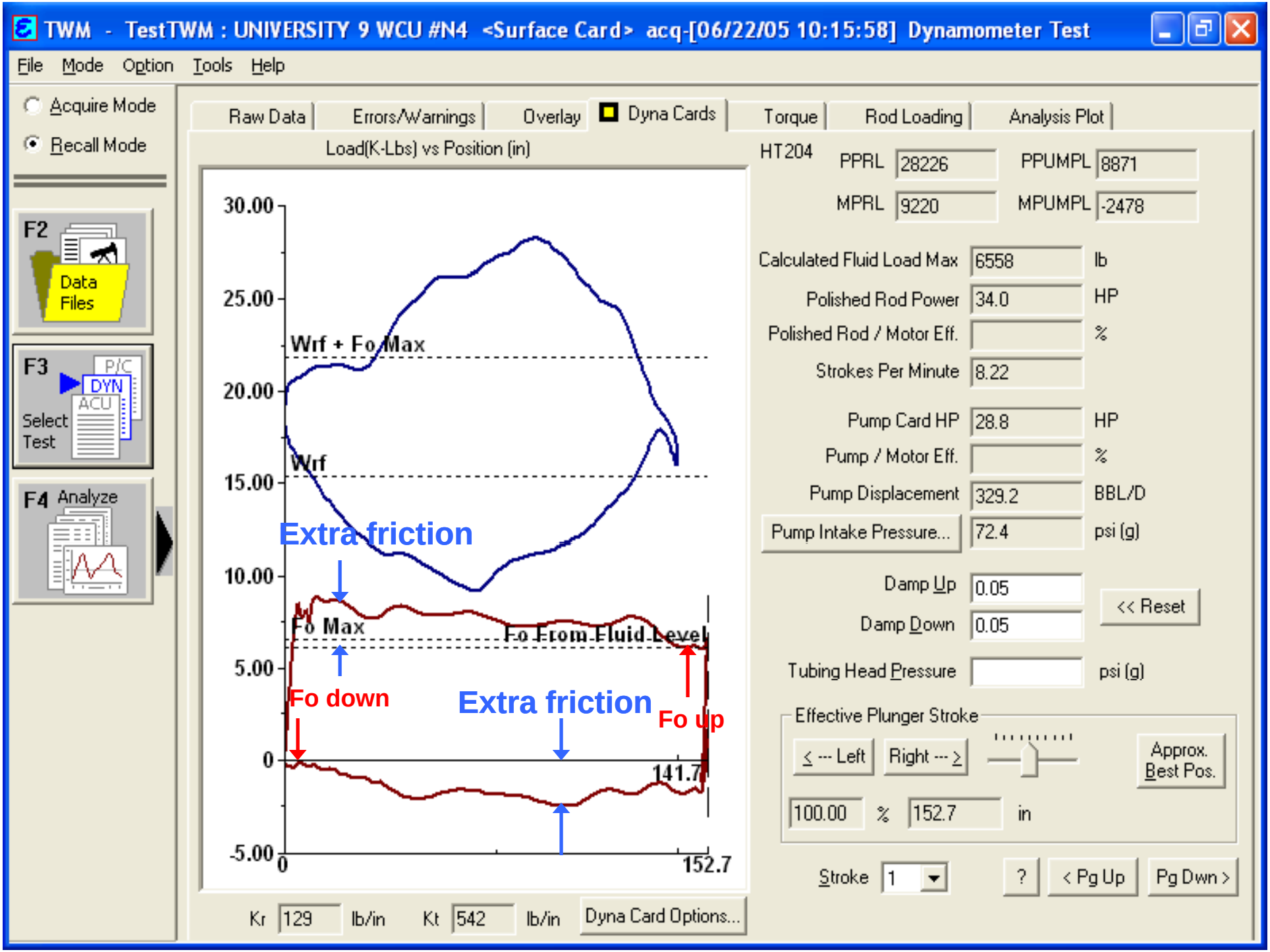


After Hot Water Treatment +100 BPD

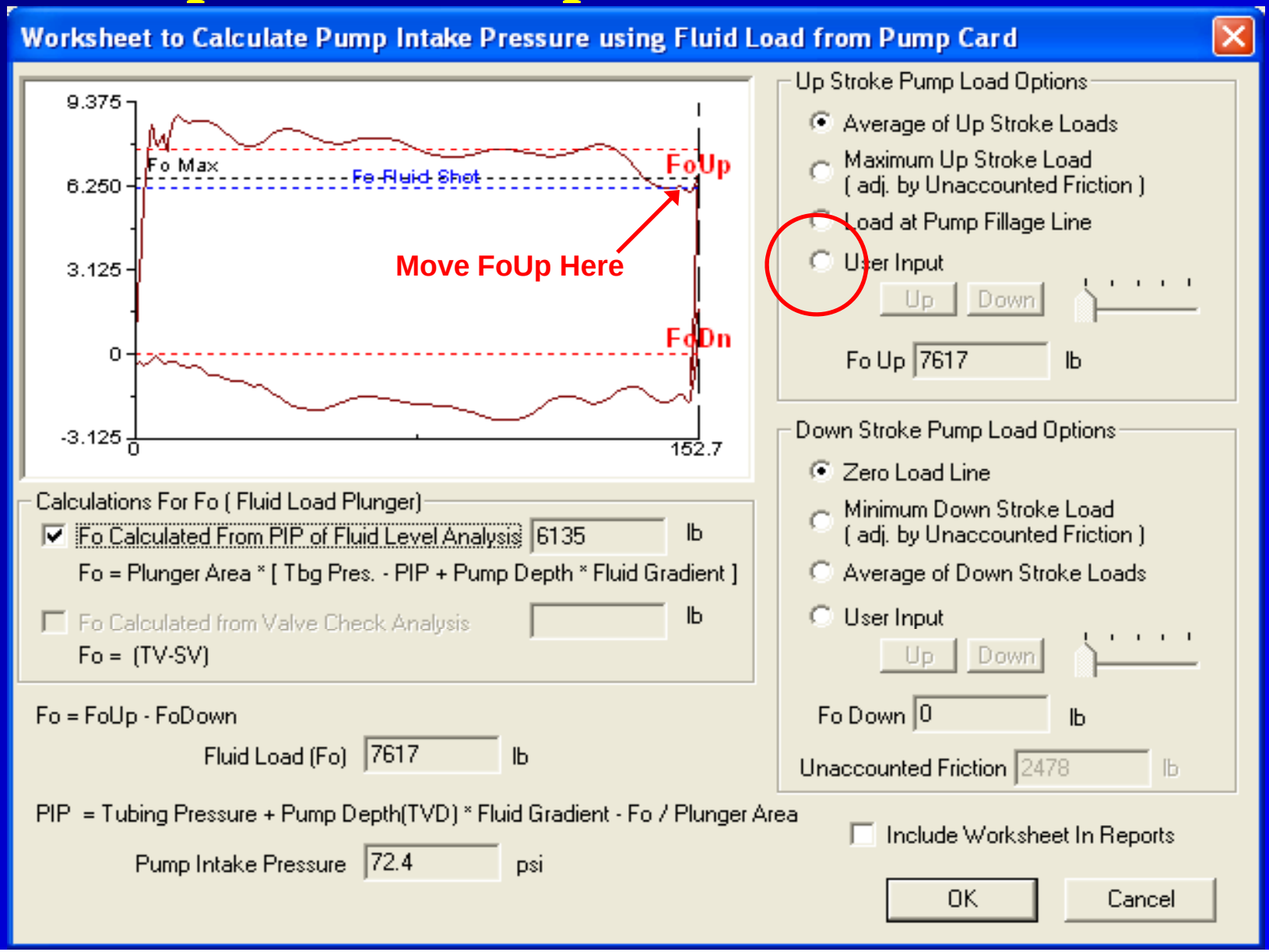


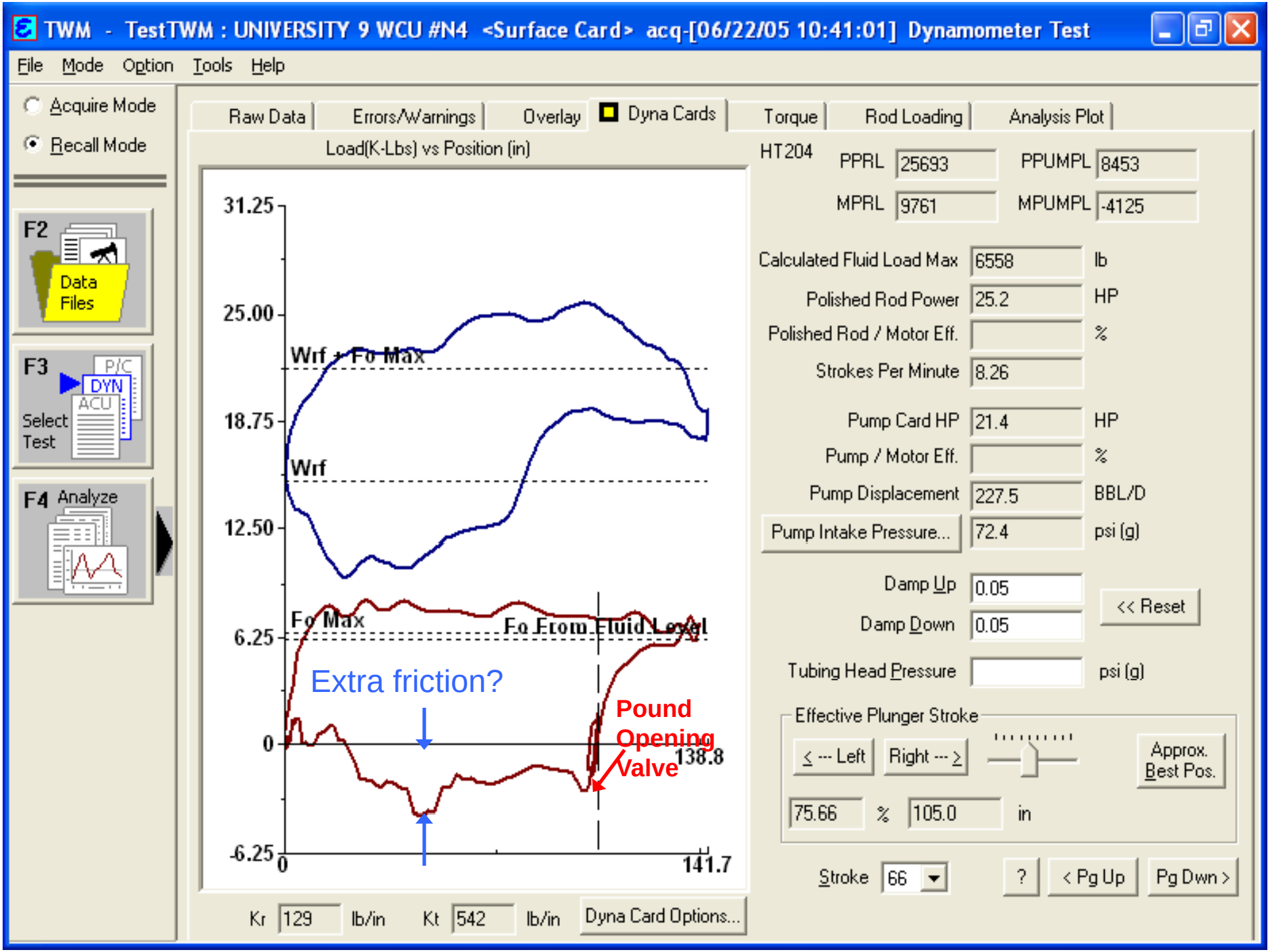
Adjusting Damping Coefficients

1. Iterative process used to estimate the proper damping coefficients
2. Note the position of the downhole dyno card when the damping coefficients are properly stated.
3. A finite amount of adjustment is further possible by fine tuning the specific gravity of the tubing fluid over the length of the rod string.
4. When the pump load lines B - C and D - A are nearly flat then the proper amount of damping has been added.
5. Concave out (like with 0.01) then need more damping.
6. Too much damping then lines B - C and D - A are concave in toward the center of the card and the damping coefficient are too high.
7. When the correct amount of damping is entered and the tubing pressure is entered, then the PIP from the pump card should be in good agreement with the PIP from the fluid level.
8. Some recommendations for default damping coefficients are approximately 0.01 per 1000 feet of well depth. For a well 3000' deep then 0.03 is a good initial guess for the value of damping.
9. Add 0.01 per 2000 feet for pump depths greater than 5000 feet.
10. ***DO NOT HAVE TO CHANGE DAMPING***; just note that downhole friction is high and PIP from Pump Card too LOW!!!

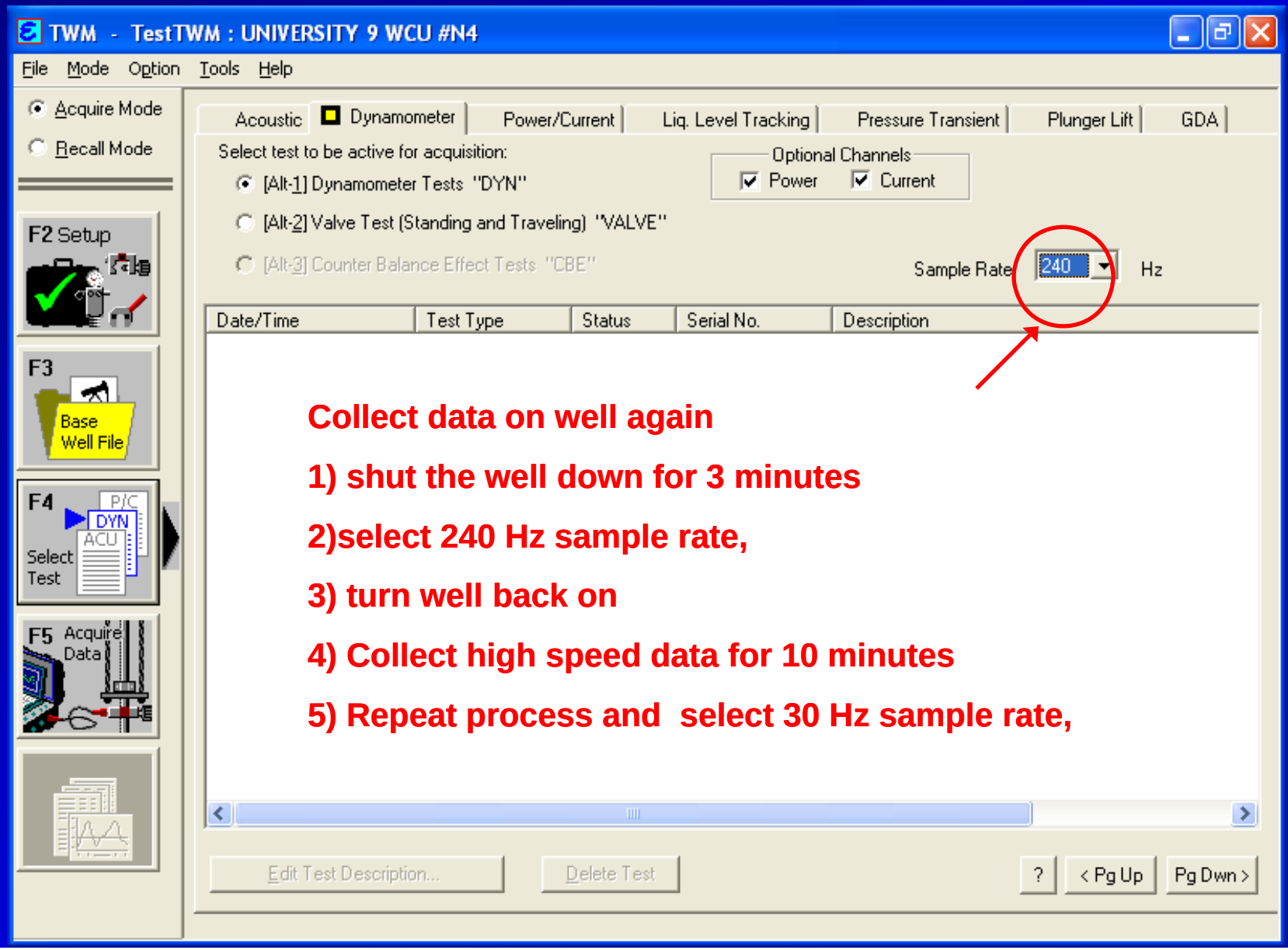

TWM - TestTWM : UNIVERSITY 9 WCU #N4 <Surface Card> acq-[06/22/05 10:15:58] Dynamometer Test
File Mode Option Tools Help
Acquire Mode
Recall Mode
F2 Data Files
F3 Select Test
P/C
DYN
ACU
F4 Analyze
Raw Data
Errors/Warnings
Overlay
Dyna Cards
Torque
Rod Loading
Analysis Plot
Load(K-Lbs) vs Position (in)
30.00
25.00
20.00
15.00
10.00
5.00
0
-5.00
0
152.7
Wrf + Fo Max
Wrf
Extra friction
Fo Max
Fo From Fluid Level
Fo down
Extra friction
Fo up
141.7
Kr 129 lb/in
Kt 542 lb/in
Dyna Card Options...
HT204
PPRL 28226
PPUMPL 8871
MPRL 9220
MPUMPL -2478
Calculated Fluid Load Max 6558 lb
Polished Rod Power 34.0 HP
Polished Rod / Motor Eff. %
Strokes Per Minute 8.22
Pump Card HP 28.8 HP
Pump / Motor Eff. %
Pump Displacement 329.2 BBL/D
Pump Intake Pressure... 72.4 psi (g)
Damp Up 0.05
Damp Down 0.05
<< Reset
Tubing Head Pressure psi (g)
Effective Plunger Stroke
< --- Left
Right --- >
Approx. Best Pos.
100.00 % 152.7 in
Stroke 1
?
< Pg Up
Pg Dwn >

Use Up Stroke Pump Load Option User Input to Move FoUp Line to the point shown below




TWM - TestTWM : UNIVERSITY 9 WCU #N4 <Surface Card> acq-[06/22/05 10:41:01] Dynamometer Test
File Mode Option Tools Help
Acquire Mode
Recall Mode
F2 Data Files
F3 Select Test
P/C
DYN
ACU
F4 Analyze
Raw Data
Errors/Warnings
Overlay
Dyna Cards
Torque
Rod Loading
Analysis Plot
Load(K-Lbs) vs Position (in)
31.25
25.00
18.75
12.50
6.25
0
-6.25
Wrf + Fo Max
Wrf
Fo Max
Fo From Fluid Level
Extra friction?
Pound
Opening
Valve
138.8
0
141.7
Kr 129 lb/in
Kt 542 lb/in
Dyna Card Options...
HT204
PPRL 25693
PPUMPL 8453
MPRL 9761
MPUMPL -4125
Calculated Fluid Load Max 6558 lb
Polished Rod Power 25.2 HP
Polished Rod / Motor Eff. %
Strokes Per Minute 8.26
Pump Card HP 21.4 HP
Pump / Motor Eff. %
Pump Displacement 227.5 BBL/D
Pump Intake Pressure... 72.4 psi (g)
Damp Up 0.05
Damp Down 0.05
<< Reset
Tubing Head Pressure psi (g)
Effective Plunger Stroke
< --- Left
Right --- >
Approx. Best Pos.
75.66 % 105.0 in
Stroke 66
?
< Pg Up
Pg Dwn >

High speed sampling may help us understand what is happening on your well



Damping

1. Unaccounted friction impacts shape of pump card; friction increases load range.
2. “Unaccounted” is extra friction not removed by the wave equation calculating pump card.
3. Damping coefficients subtract “friction” from rods as function of velocity.
4. 0.05 Default damping usually works OK.
5. Change TWM damping coefficients from the default to “Sort of” account for friction.
6. Wells having shallow depth with out much deviation; damping coefficients are usually 0.01/1000 foot depth. Use 0.01/2000’ for pump depths greater than 5000’.
7. Increase damping as the downhole fiction goes up or decrease damping as the well gets shallower.