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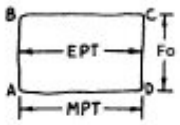
Generalized Synthetic Pump Cards

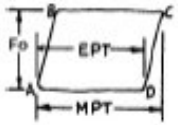
The following pump cards are in two (2) groups: 1) the group of cards on the left has tubing anchored and 2) the group on the right has unanchored tubing. These generalized synthetic pump cards represent pumping systems experiencing some of the more common problems. The cards illustrate different pumping conditions and malfunctions of downhole equipment. The terms shown are as follows:

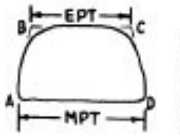
MPT = Maximum Plunger Travel
EPT = Effective Plunger Travel
Fo = Differential Load On Plunger

ANCHORED UNANCHORED

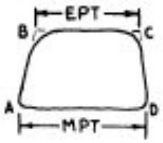


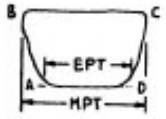
Normal Pumping-Full liquid and no gas. Pump functioning properly. With tubing anchored, EPT=MPT. With unanchored tubing, EPT<MPT.



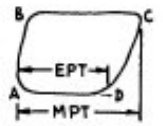


Leaking traveling valve, TV, or excessive plunger slippage causes delay in picking up fluid load from A to B and premature unloading from C to D, (the traveling valve, TV, is effective only during a portion of the upstroke).

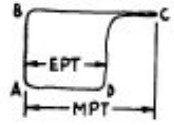




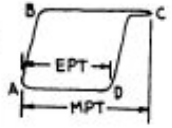
Leaking standing valve, SV, causes premature loading of rods from A to B, and a delay in unloading from C to D, (the standing valve, SV, is effective only during a portion of the downstroke.

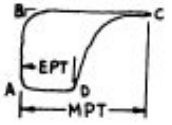


ANCHORED UNANCHORED

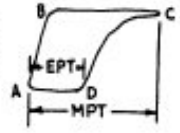


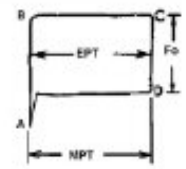
Severe fluid pound, well is being pumped off. Pump components functioning properly.



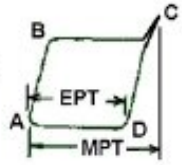


Gas interference is causing loss of EPT. Pump components functioning properly. Unstable well conditions exist when EPT changes from stroke-to-stroke.





Pump is tapping at bottom of stroke(left) and pump is tapping on top of stroke(right).

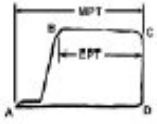


Practically any combination of the malfunctions shown above may exist in any well. The effects of these malfunctions may be superimposed on one another and the combined effect may be masked. For instance, the presence of gas interference and a tubing anchor that is has become unseated may exhibit a card whose individual effects may not readily be evident. The tubing stretch constant, K, superimposed on the card may afford an insight into the problem.

Anchored or Unanchored Tubing

(Left) Worn out pump. No apparent tubing movement in either case.

(Right) Traveling Value not closing properly. Flow restricted by very viscous fluid in pump or flow area smaller than plunger above pump to small.



Echometer Help Center
(Technical Note)

8.5 x 11 in

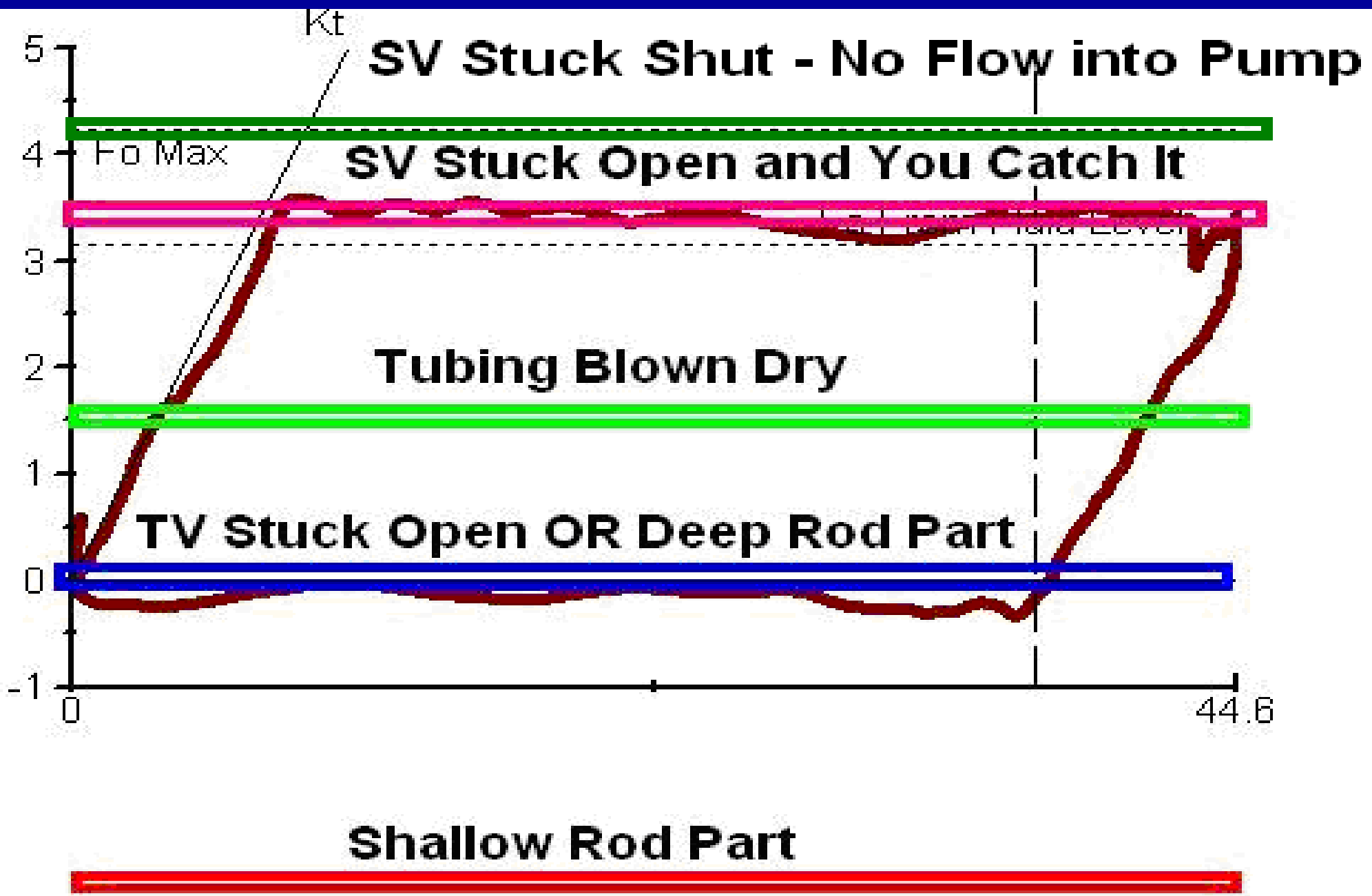
http://www.echometer.com/support/technotes/pumpcards.html

Done My Computer

Flat Pump Card Load Lines

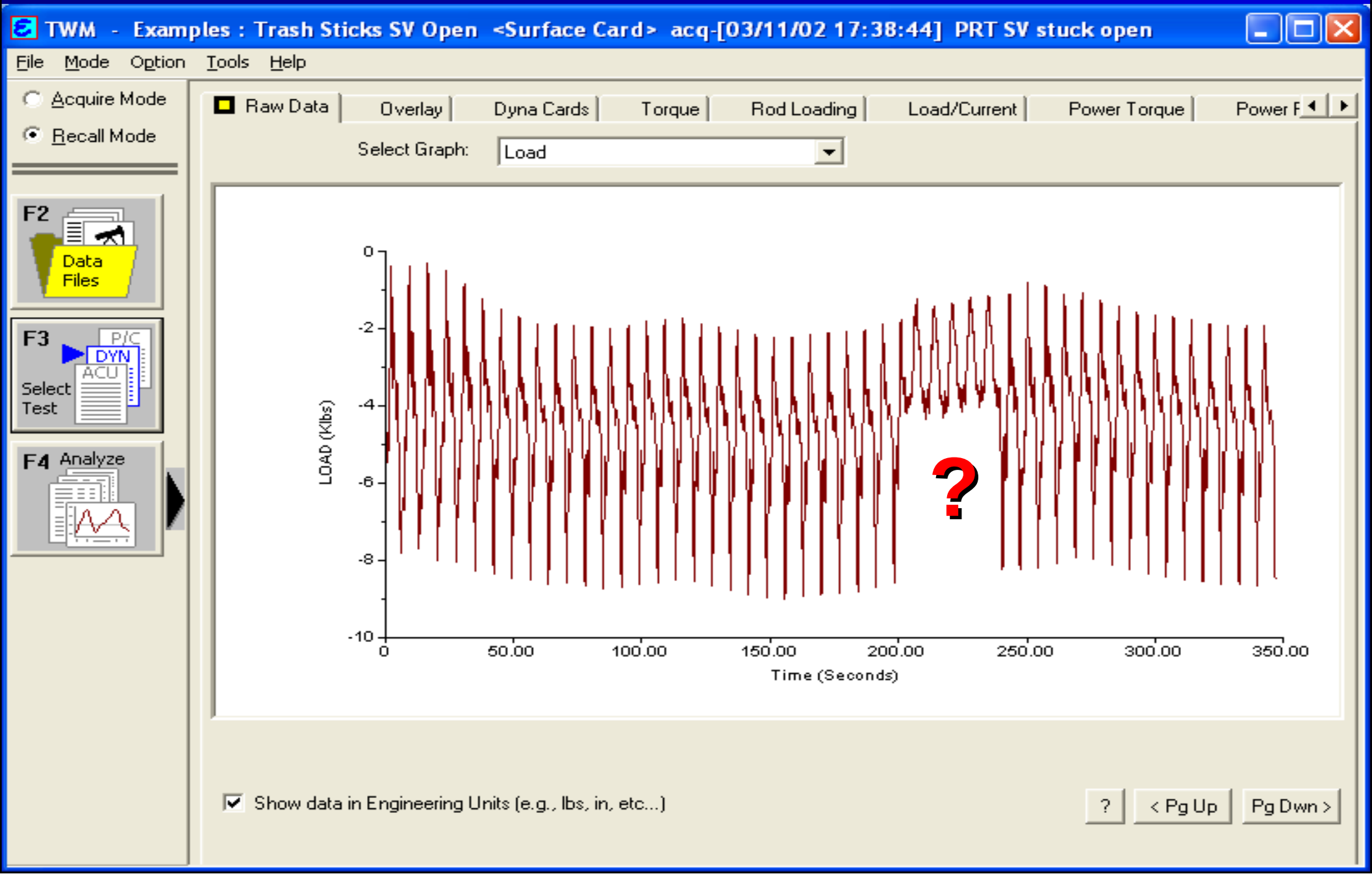
1) TV Stuck Open - Looks like Deep Rod Part but you can often tag or jar the rods and knock the debris out of the pump and re-start pump action.
2) Deep Rod Part – Plots on the Zero Load Line
3) Shallow Rod Part – Plots below the Zero Load Line by the amount of missing rod weight in fluid no longer attached 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

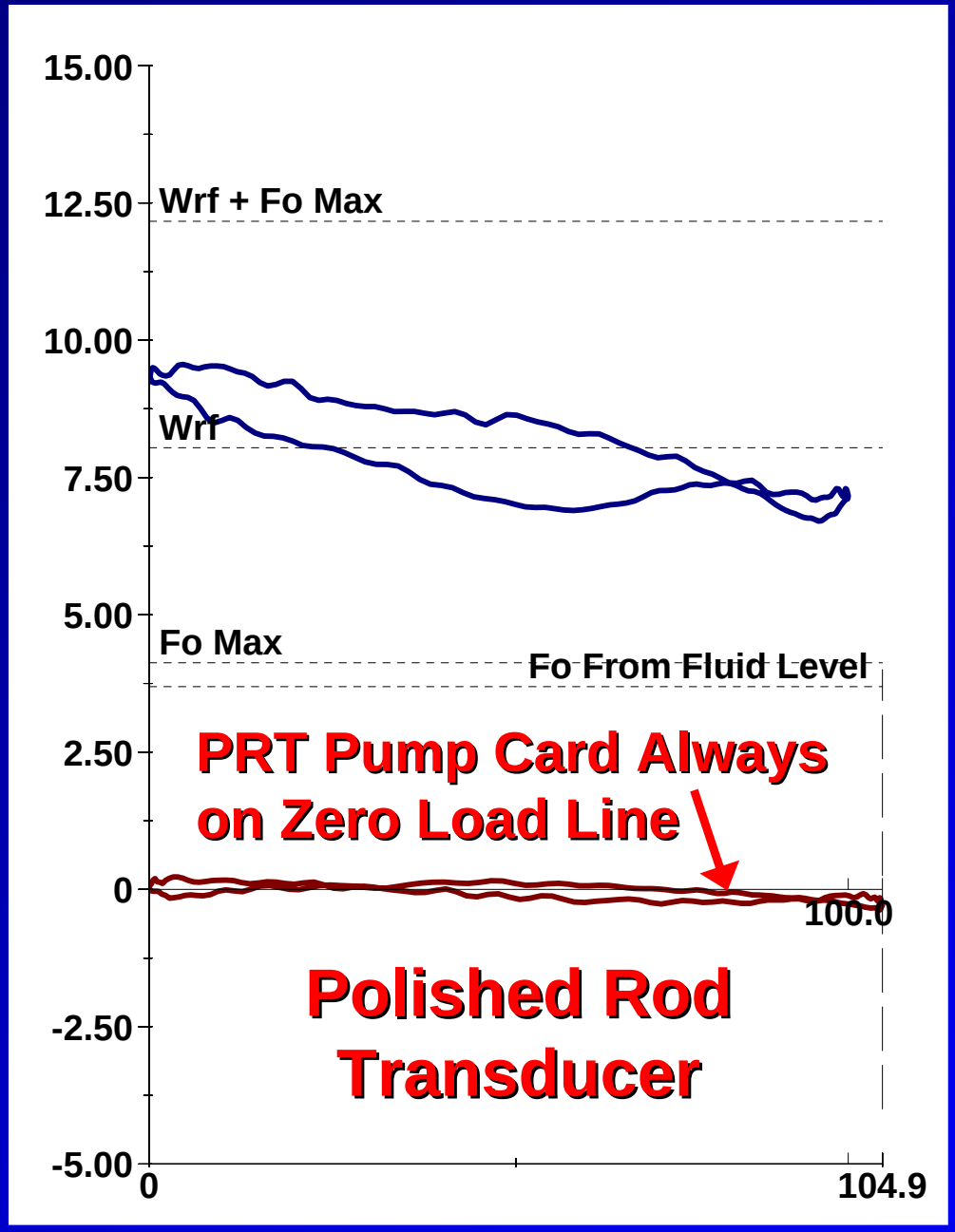


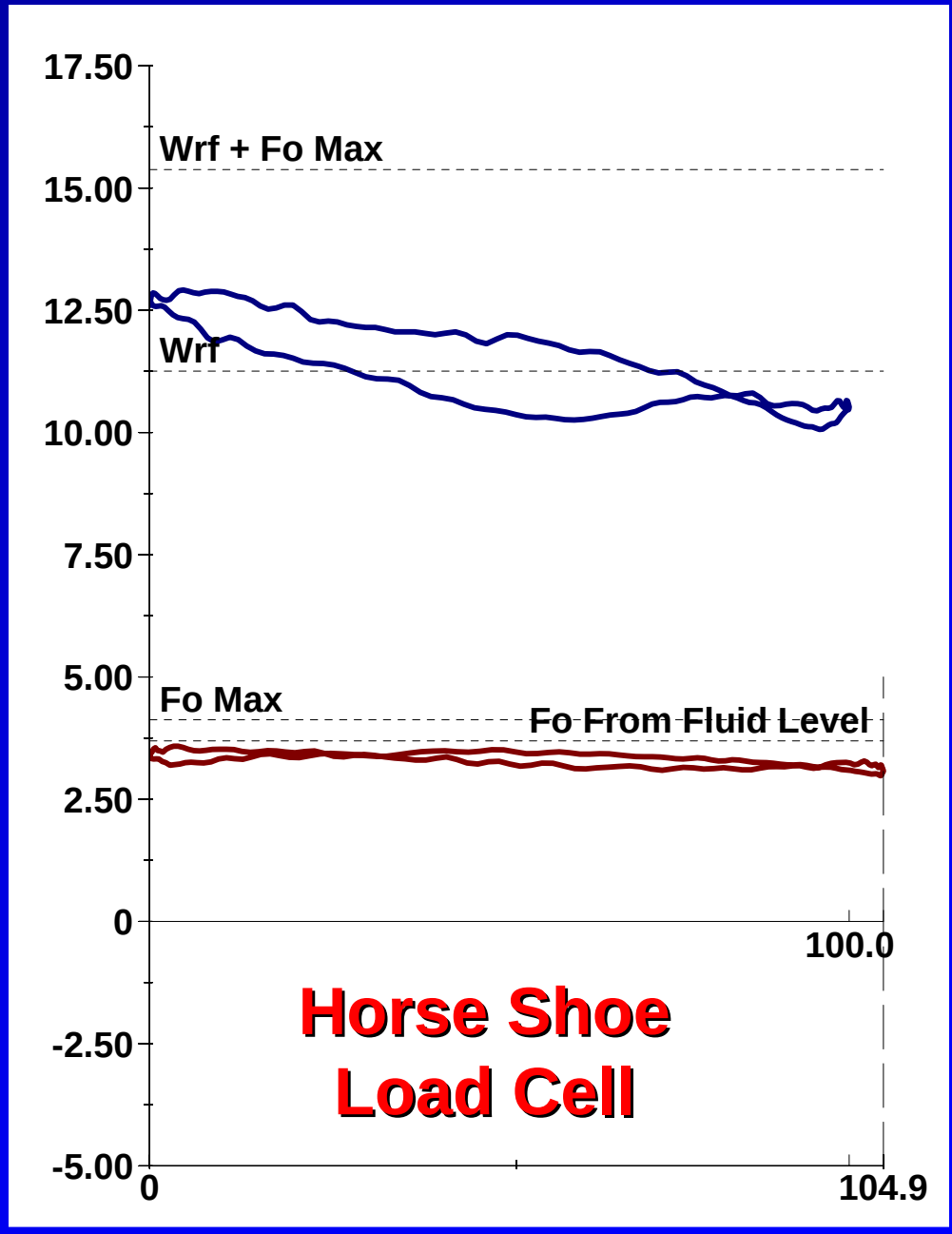
SV Sticks Open

Strokes 29-34 SV Missing

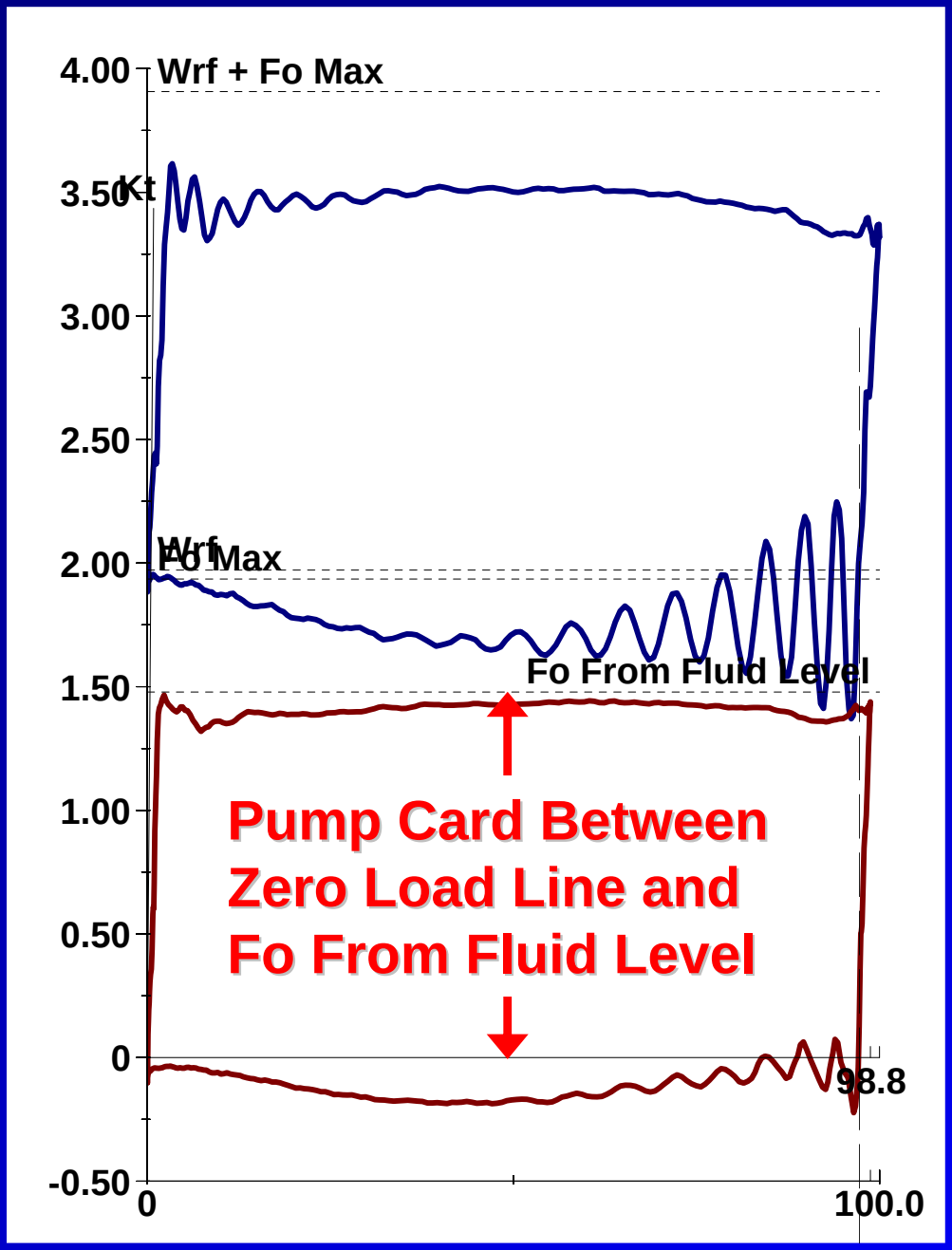


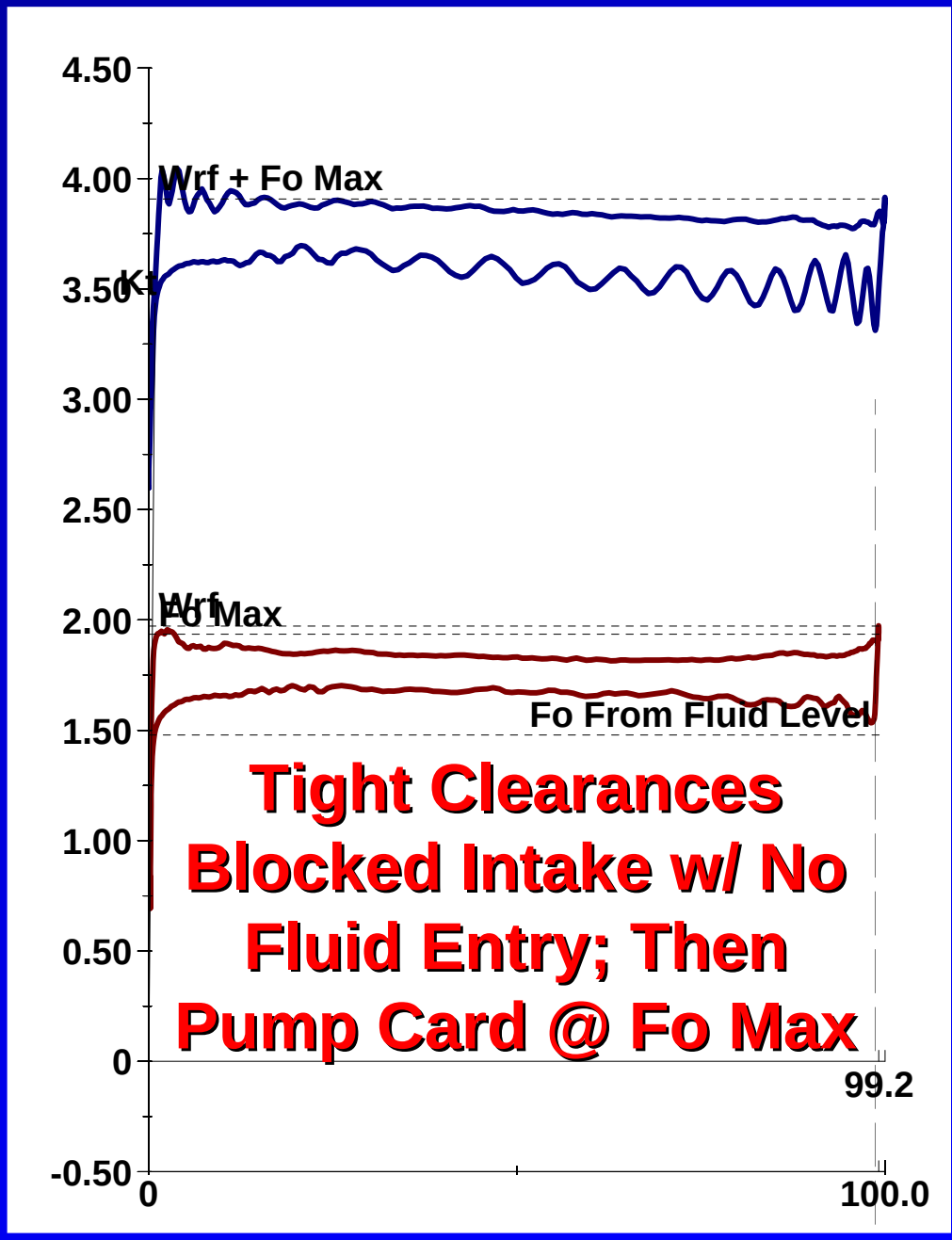
SV Sticks Open ~ TV OK?





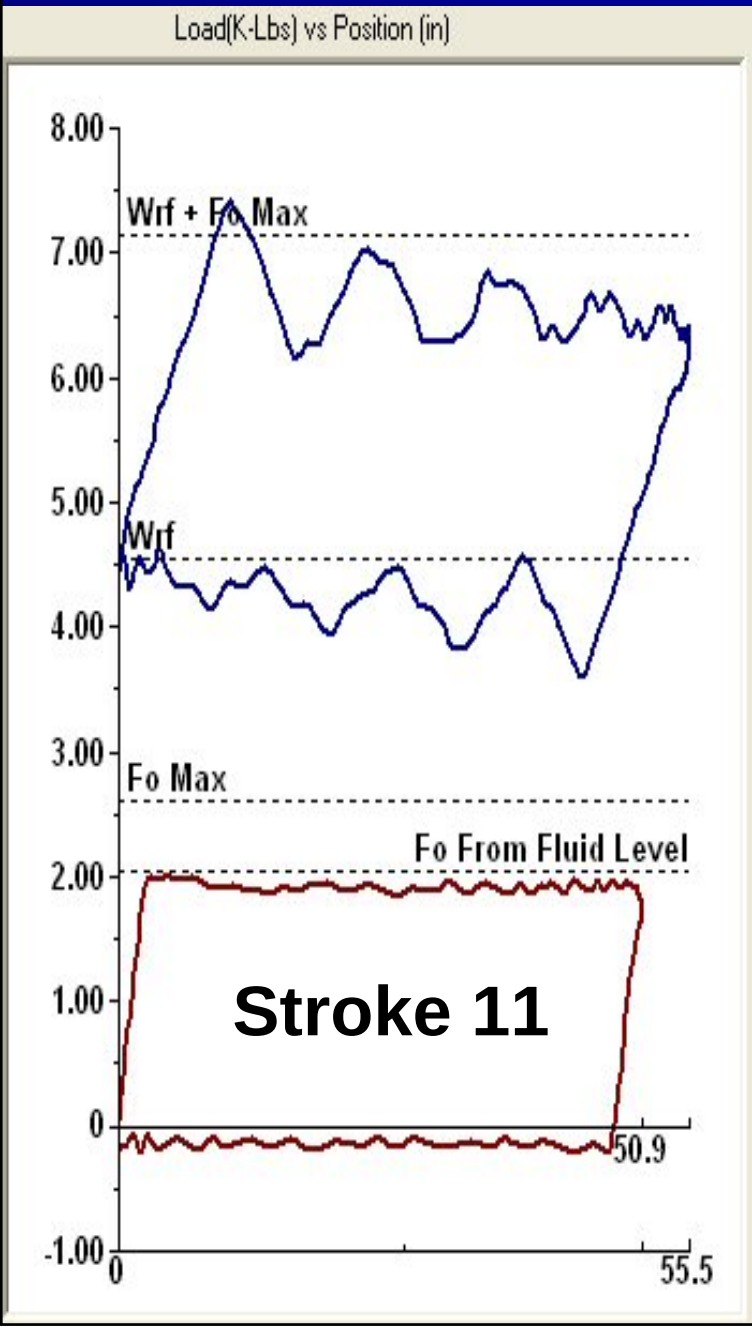
SV Stuck Closed ~ TV OK?





Lost TV Load

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



HT660

PPRL	7415	PPUMPL	1996
MPRL	3612	MPUMPL	-229

Calculated Fluid Load Max	2610	lb
Polished Rod Power	1.8	HP
Polished Rod / Motor Eff.		%
Strokes Per Minute	6.04	
Pump Card HP	1.5	HP
Pump / Motor Eff.		%
Pump Displacement	76.6	BBL/D
Pump Intake Pressure...	319.2	psi (g)
Damp Up	0.05	
Damp Down	0.05	
Tubing Head Pressure	58.0	psi (g)

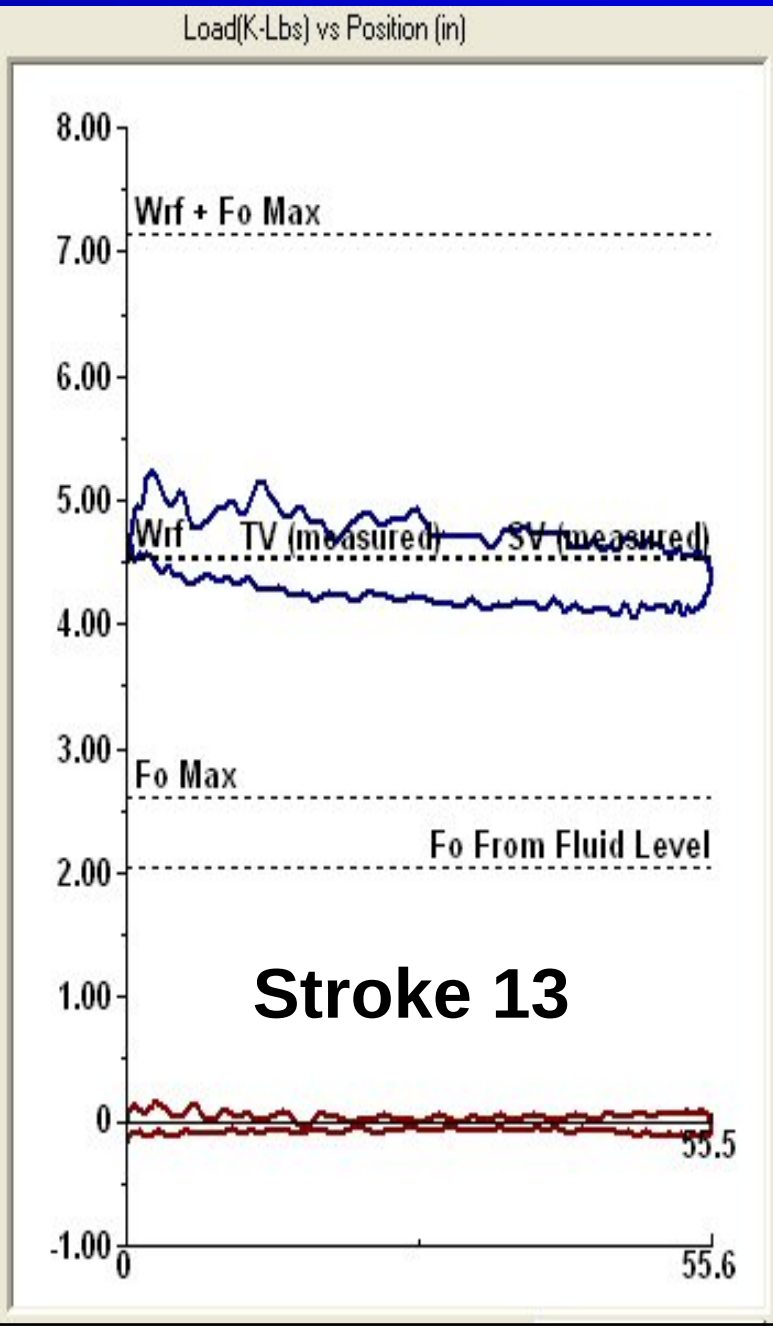
<< Reset

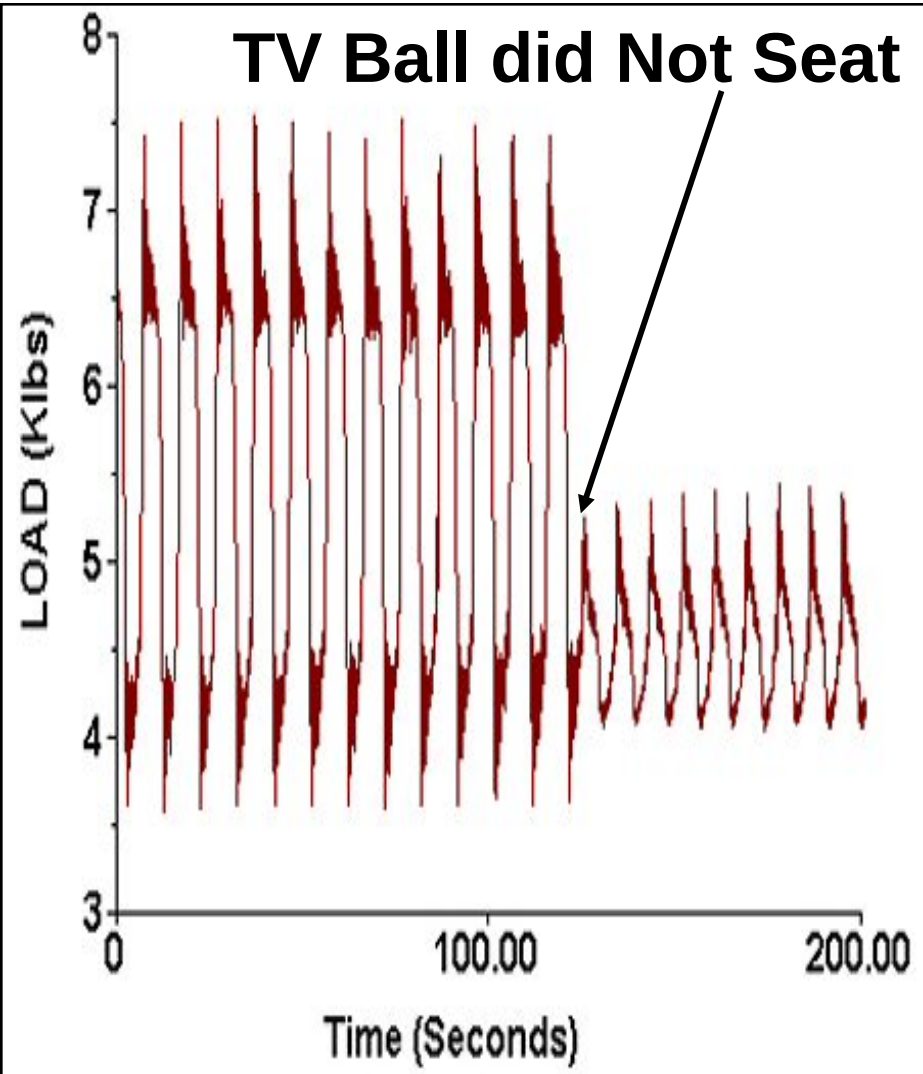
Effective Plunger Stroke

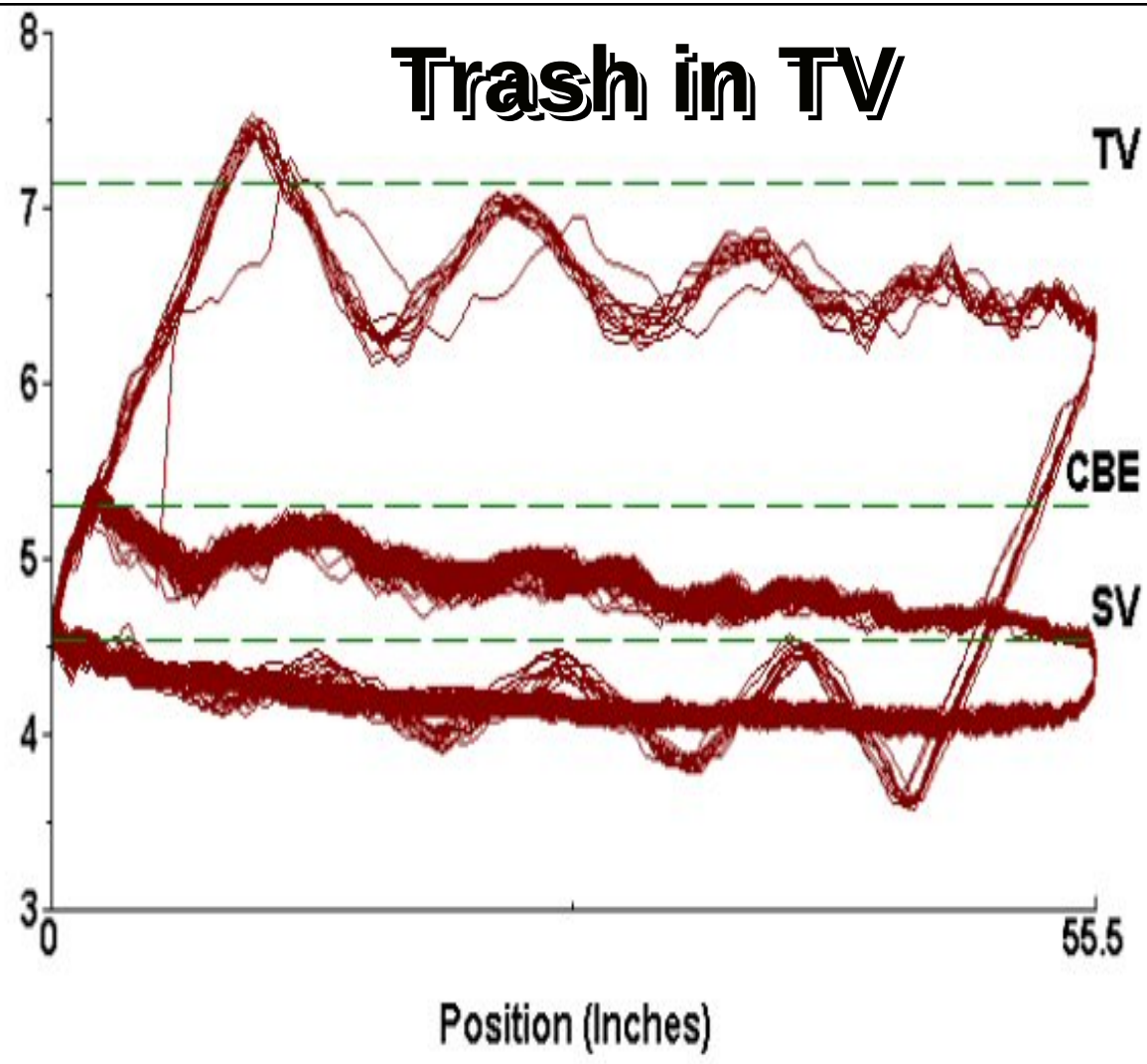
< --- Left | Right --- > | Appr Best

95.06 % 48.4 in

Stroke 11 ? < Pg Up Pg I

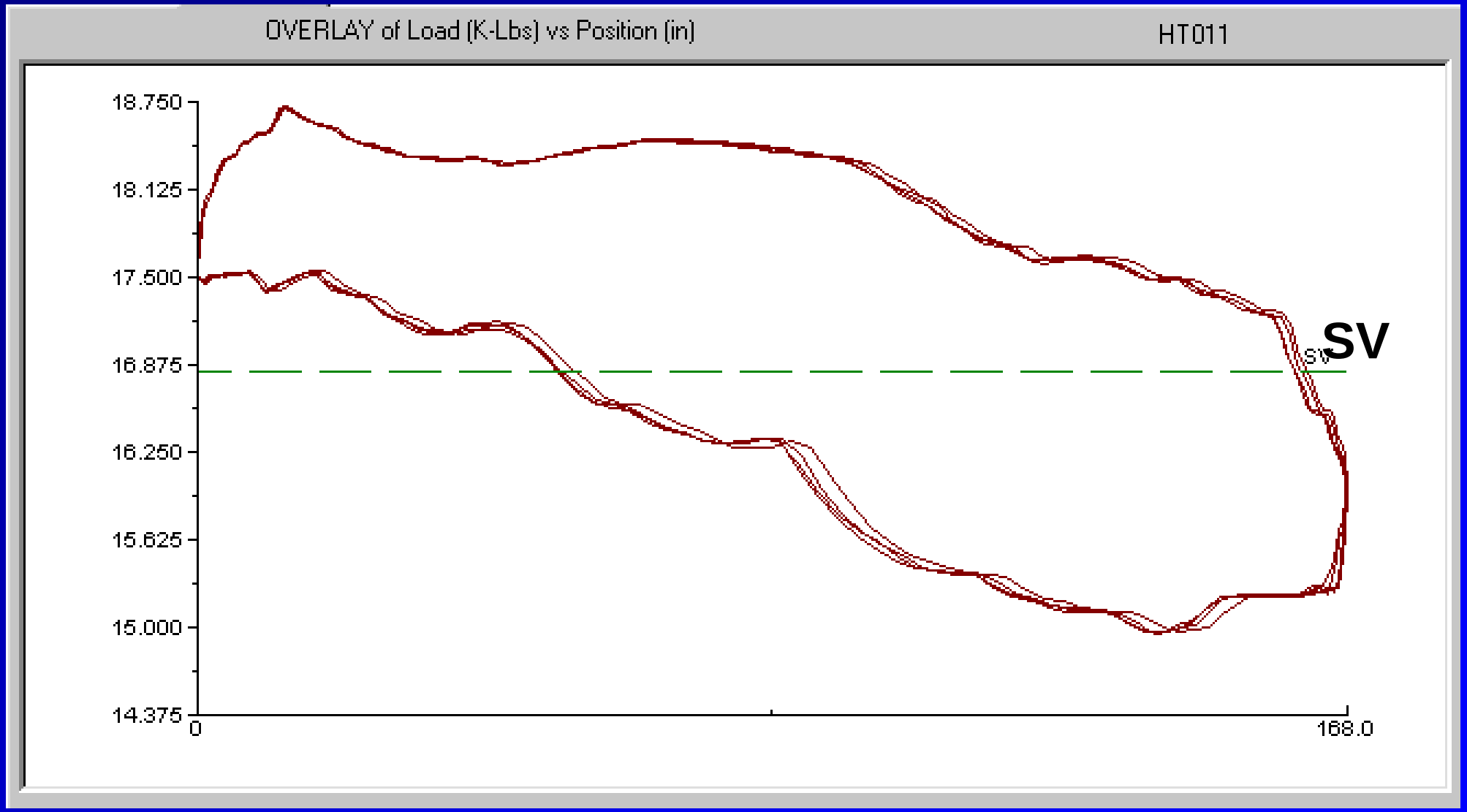


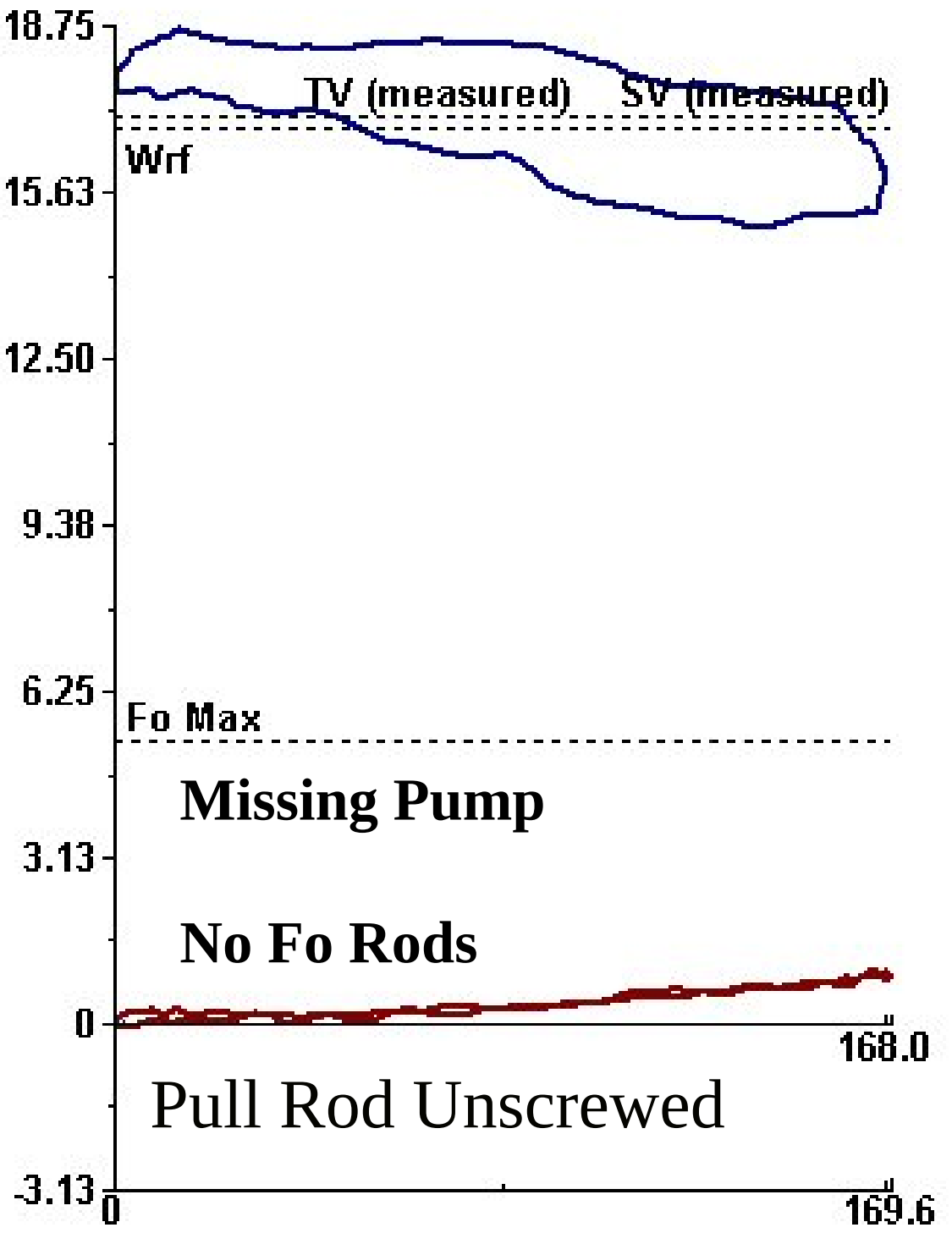




Trash in TV Notice normal appearing Surface Dynamometer Card, on the 13th stroke TV became stuck open due to trash. Same type of surface card could occur, if Pump unseated, Pull Rod became unscrewed or parted, or rods parted at the pump.

Surface card OK. Pump 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.

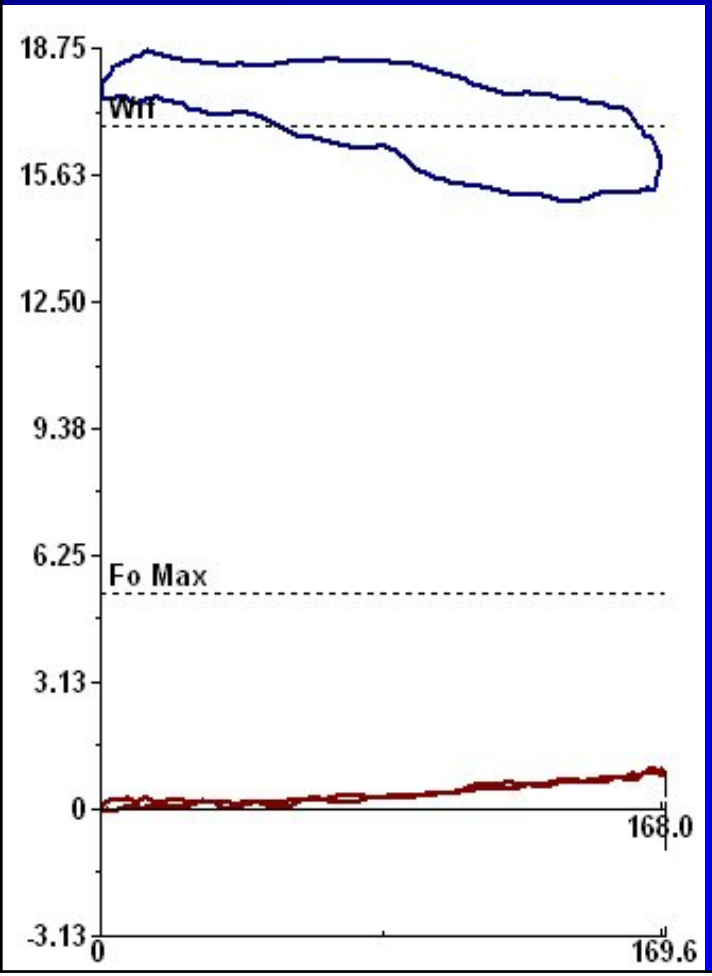
Sometimes trash in the pump keeps the traveling valve ball from going on seat. Tagging on the down stroke before pulling, may knock out trash.

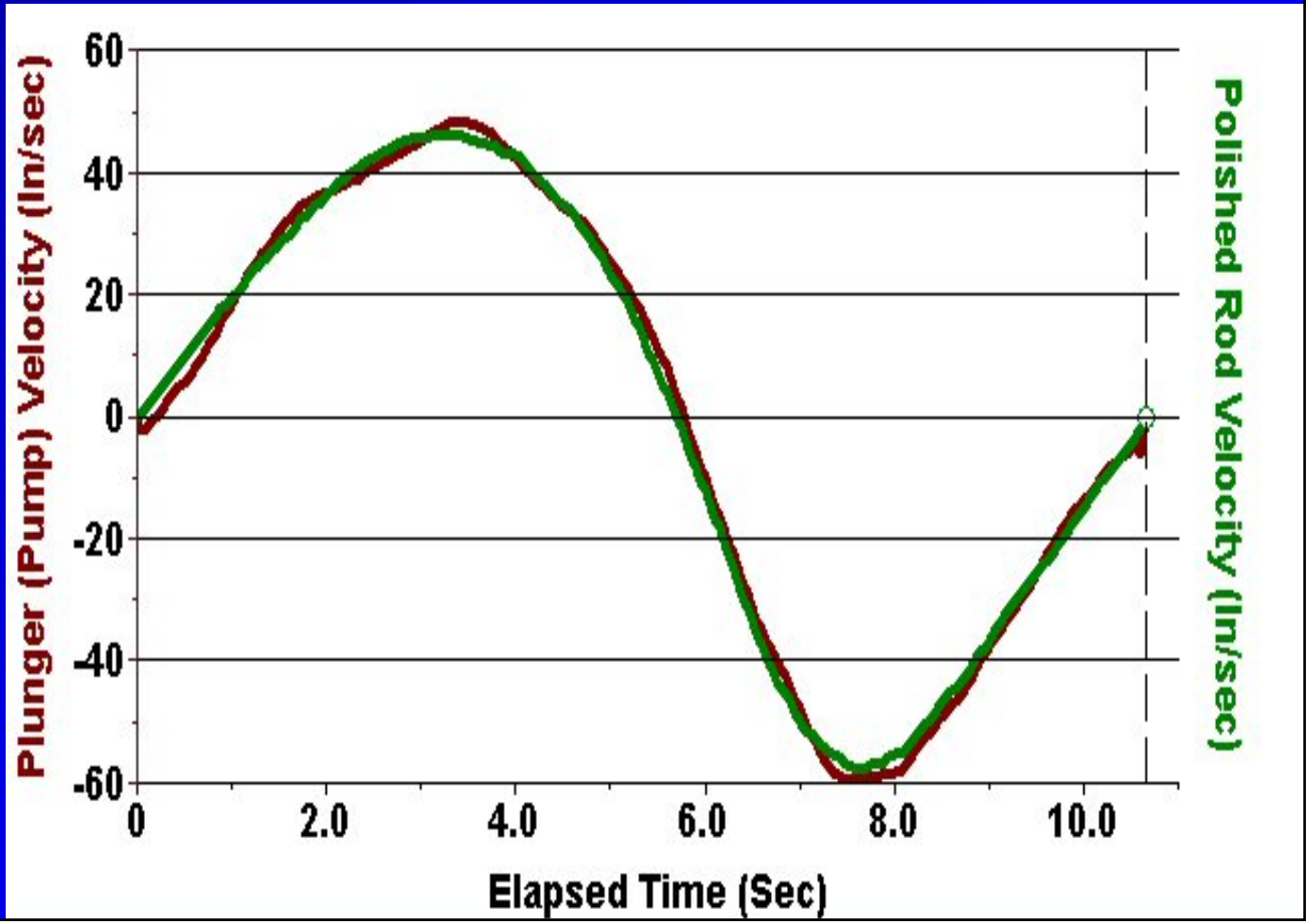
Deep Rod Part

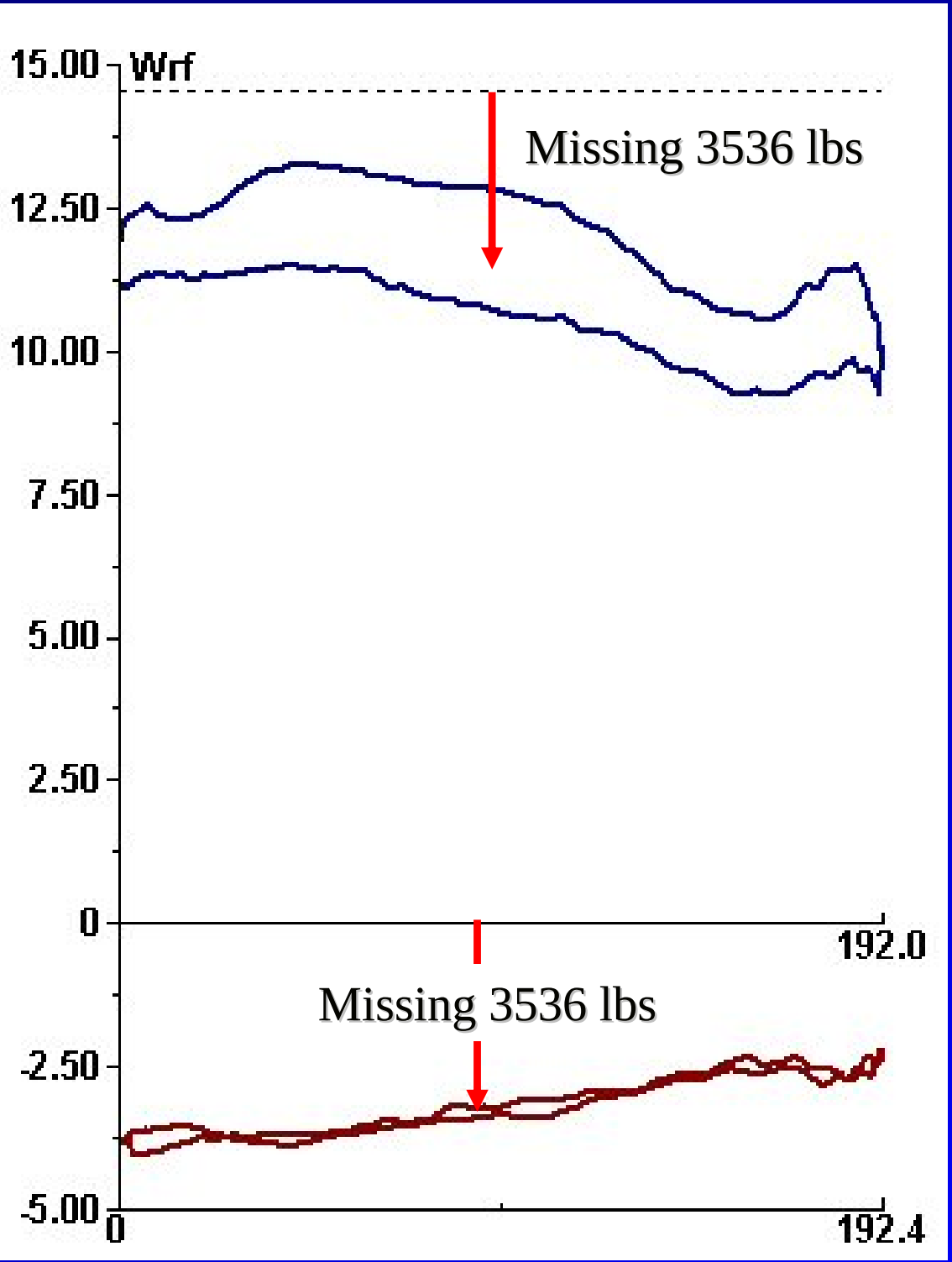
Pull Rod on Pump Parted

Plunger & Polished Rod Velocity Equal

1. No Fluid Produced to Surface
2. No Fluid Load – No Pump – No Rod Stretch
3. Plunger Does Not Stop while Rods Stretch
4. Momentum of Rod String results in Slight Over-travel of Rods at Pump Depth







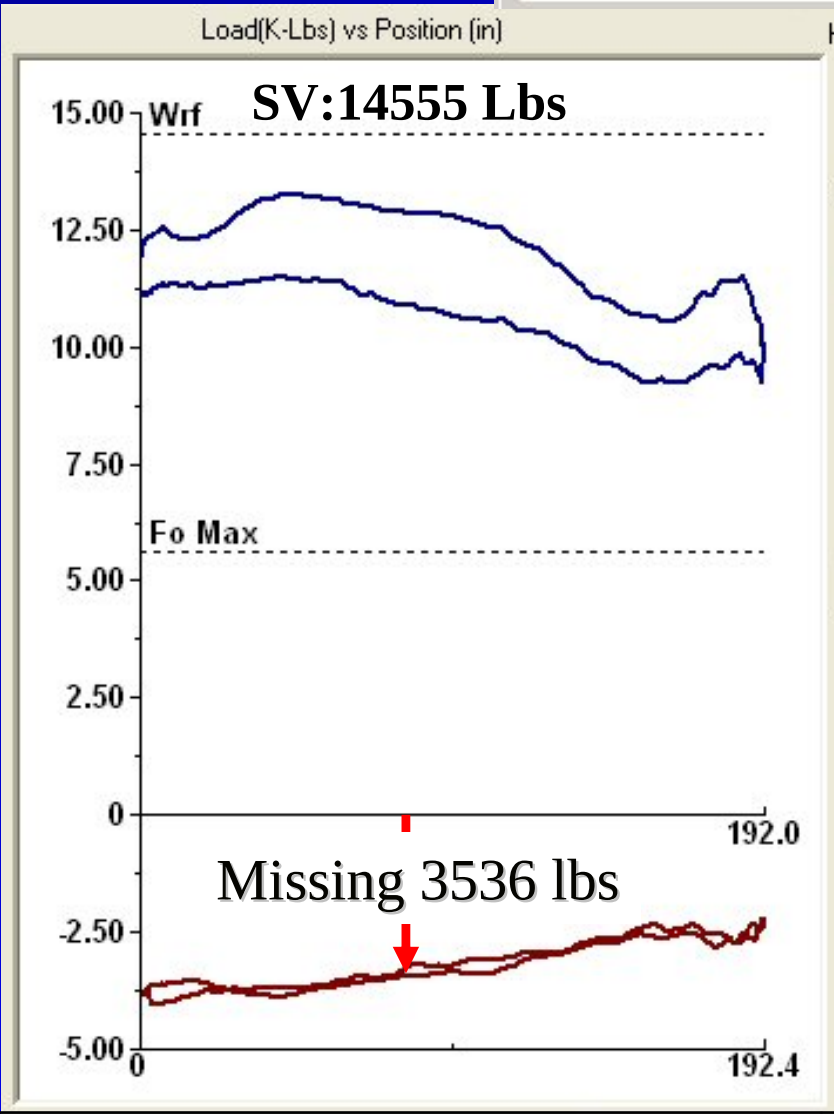
Rods Parted Higher Above Pump results in dynamometer cards load measured below weight of rods in fluid. The actual location of the rod part will determine the trace's relative position with respect to the theoretical weight of rods in fluid.

Rod parted at a depth of 5365 feet results in 3536 lbs missing weight of rods in fluid.

Missing 37 3/4" Rods Parted 5365'

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

Missing:
Wrf 3536 lbs



[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

HT5007

PPRL	13232	PPUMPL	-2207
MPRL	9220	MPUMPL	-4077

Calculated Fluid Load Max	5625	lb
Polished Rod Power	4.7	HP
Polished Rod / Motor Eff.		%
Strokes Per Minute	6.06	
Pump Card HP	-0.2	HP
Pump / Motor Eff.		%
Pump Displacement	286.2	BBL/D
Pump Intake Pressure...	4920.7	psi (g)

Damp Up 0.05 Damp Down 0.05 << Reset

Tubing Head Pressure 150.0 psi (g)

Effective Plunger Stroke

< --- Left Right --- > Approx. Best Pos.

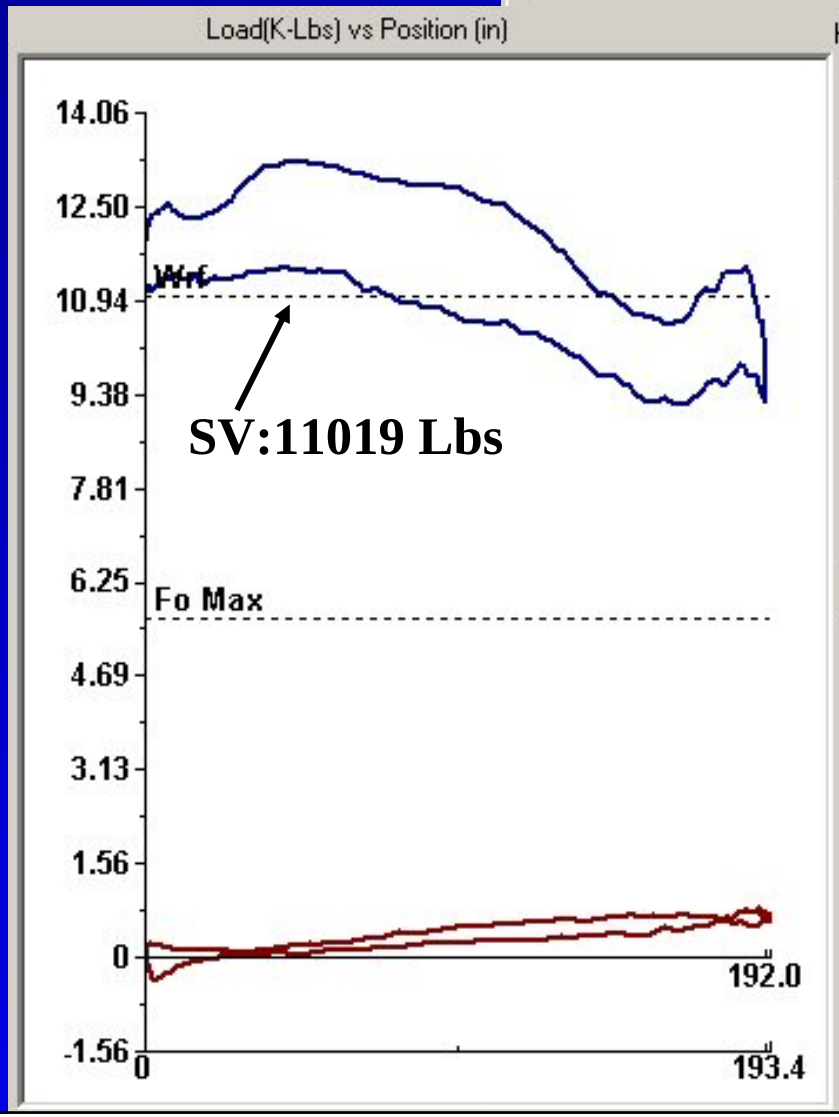
93.53 % 180.0 in

Stroke 1 ? < Pg Up Pg Dwn >

Missing 37 3/4" Rods Parted 5365'

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

No Pump
No Fo Rods



[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
Damp Down 0.05
<< Reset

Tubing Head Pressure 150.0 psi (g)

Effective Plunger Stroke

< --- Left | Right --- > | Approx. Best Pos.

93.53 % 180.9 in

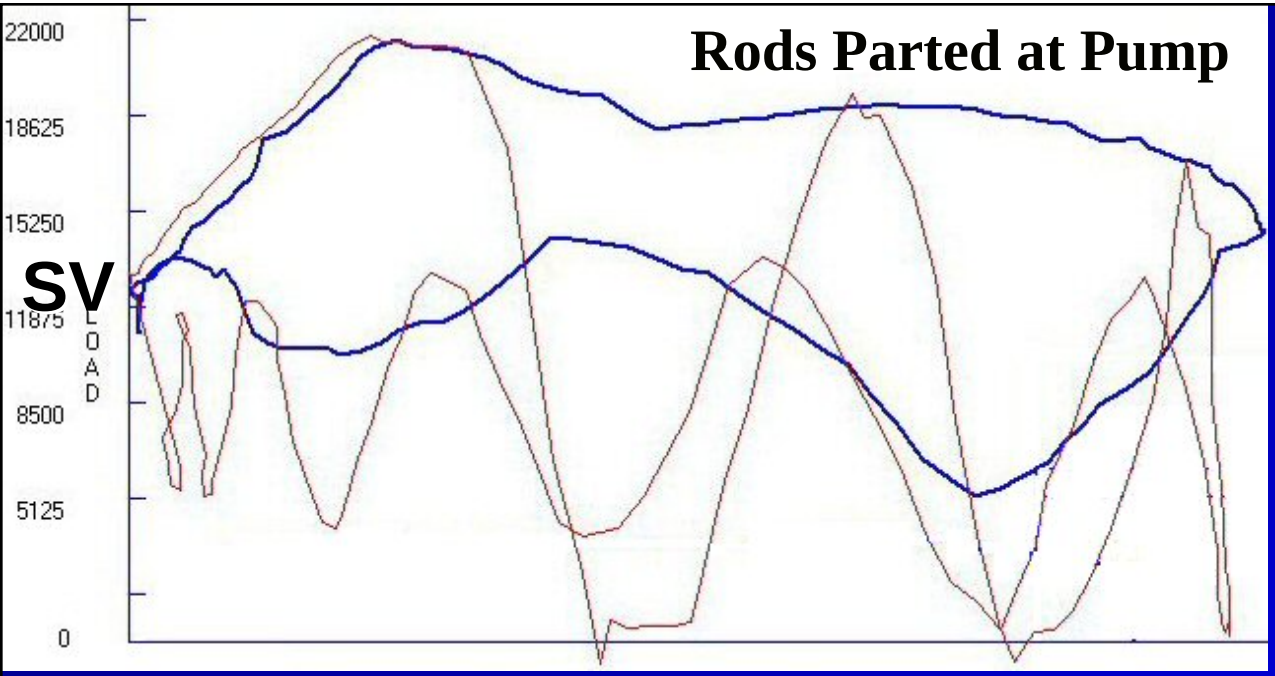
Stroke 1 ? < Pg Up Pg Dwn >

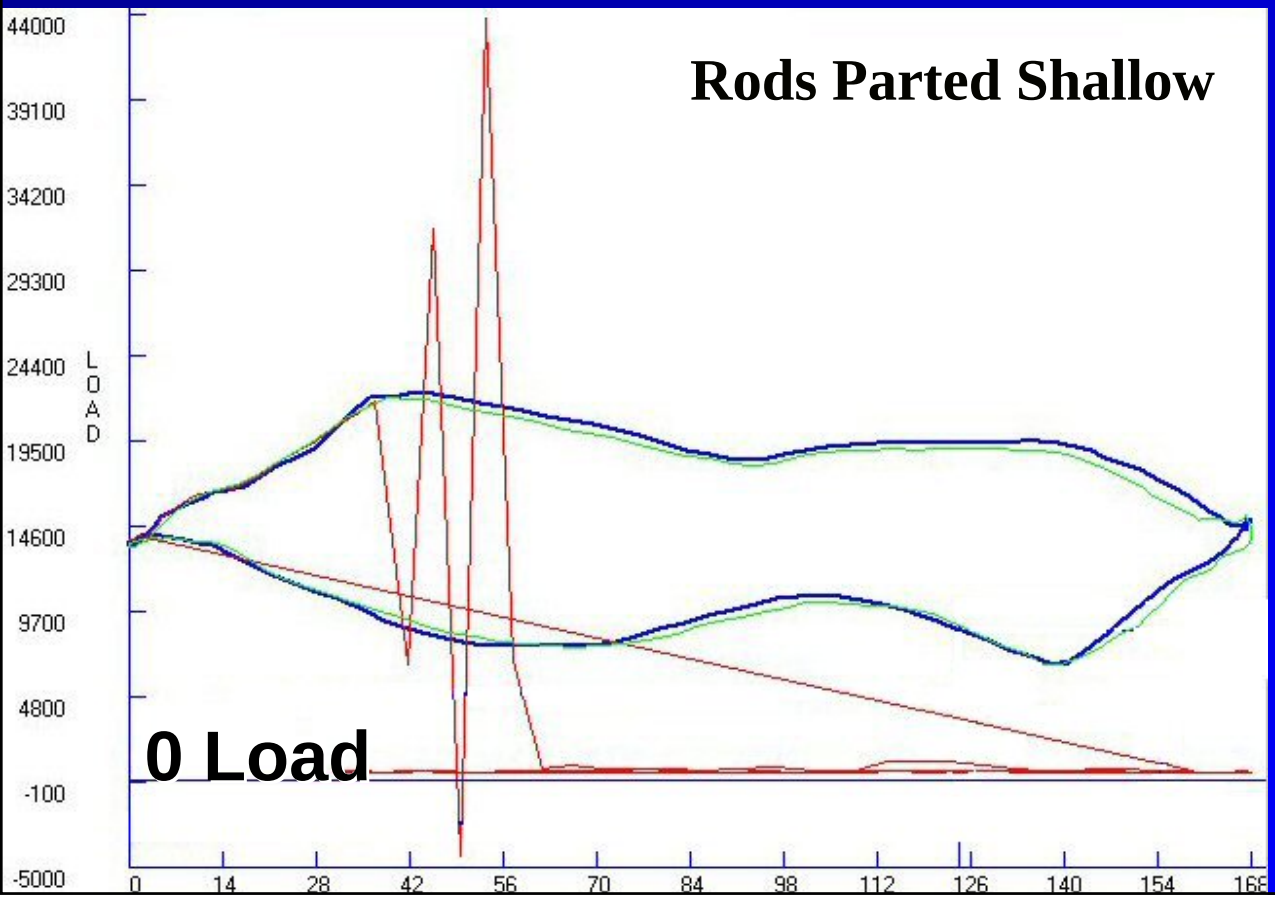
Location of Pump Card with Respect to Basic Loads are Critical to Analysis

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.



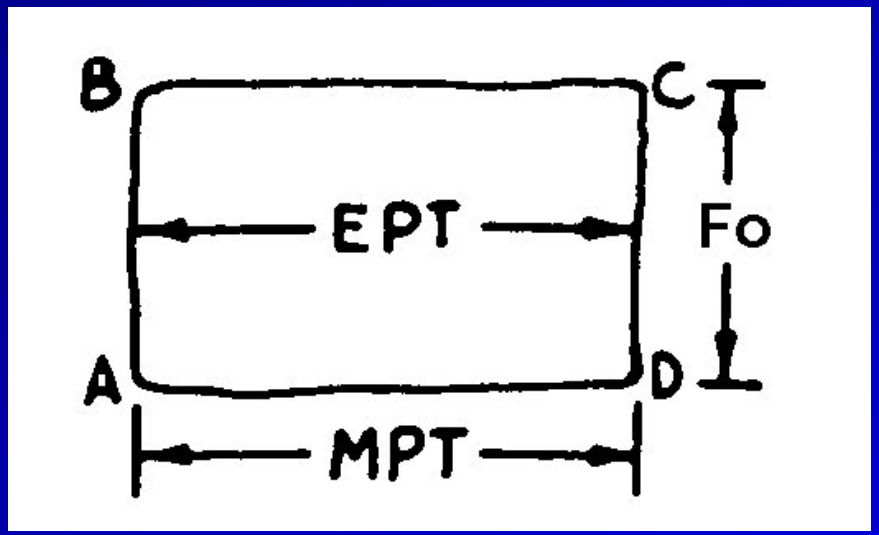


Rod Parts

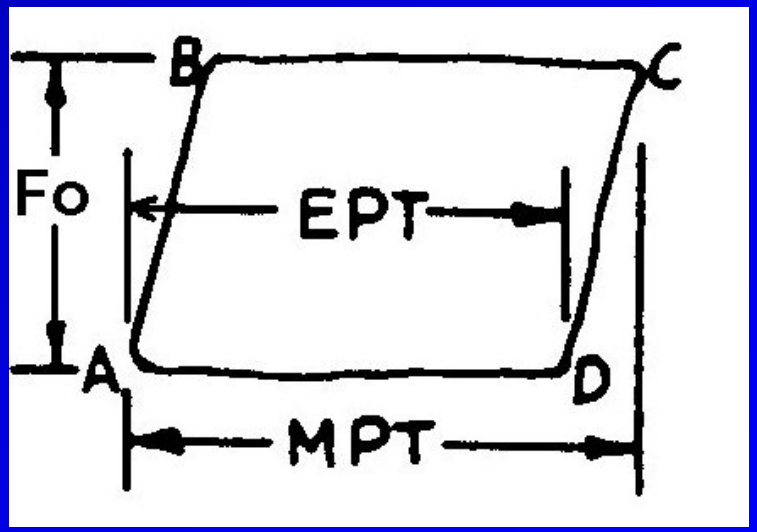
1. Usually Rod Part occurs at or near peak load.
2. Deep Rod Part Load Ended Near SV Load.
3. Shallow Rod Part Load Ended Near Zero Load Line.
4. Both Polished Rods came off the carrier bar.
5. Shallow Rod part releases more energy and usually results in more damage to Surface Equipment and Rod String.

Synthetic Pump Cards: Normal Full Pump

Tubing anchored, EPT=MPT.



Unanchored tubing, EPT<MPT

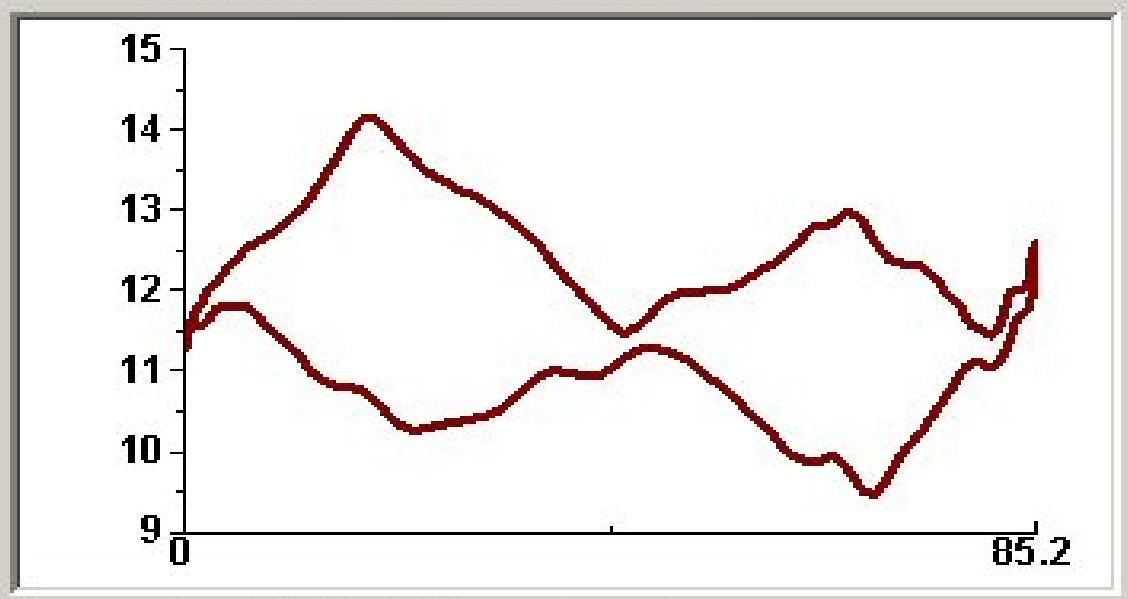


1. **Pumping-Full of Liquid**
2. **No gas in Pump.**
3. **Valves Not Leaking**
4. **Pump functioning properly.**

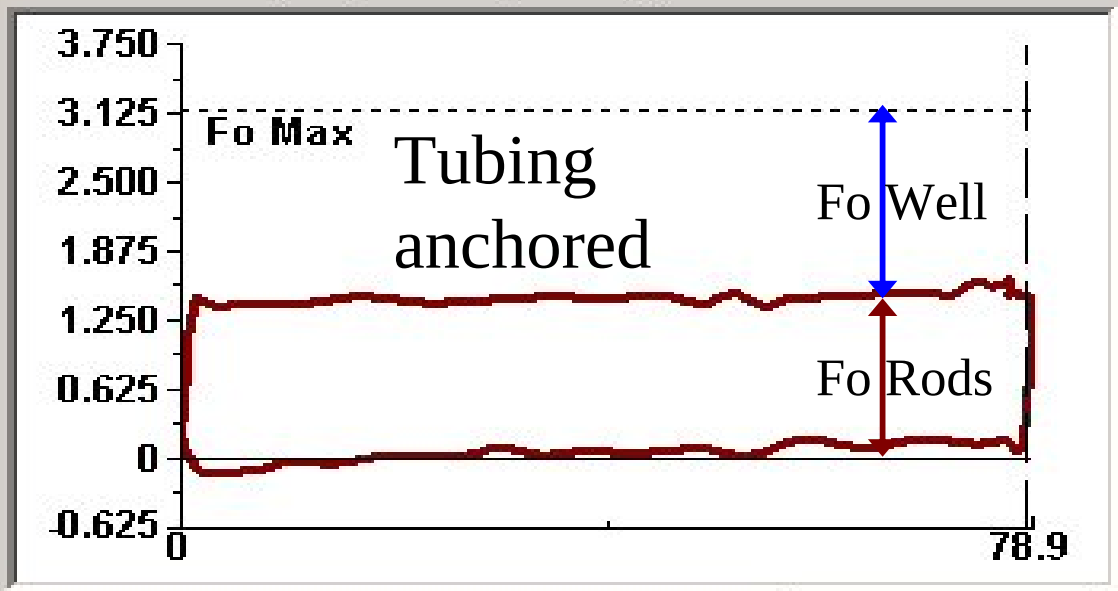
TV OK - Tubing Leak, No Fluid to Surface

Raw Data | Errors/Warnings | Overlay | Dyna Cards | Torque | Rod Loading | Analysis Plot

Load (K-Lbs) vs Polished Rod Pos. (in)



Load (K-Lbs) vs Plunger Pos. (in)



Kr 171 lb/in Kt 461 lb/in Dyna Card Options...

PRT138

PPRL	14158	PPUMPL	1615
MPRL	9482	MPUMPL	-131

Calculated Fluid Load Max	3147	lb
Polished Rod Power	2.5	HP
Polished Rod / Motor Eff.		%
Strokes Per Minute	6.59	
Pump Card HP	1.8	HP
Pump / Motor Eff.		%
Pump Displacement	94.0	BBL/D
Pump Intake Pressure...	1381.7	psi (g)
Damp Up	0.04	
Damp Down	0.04	
Tubing Head Pressure	30.0	psi (g)

<< Reset

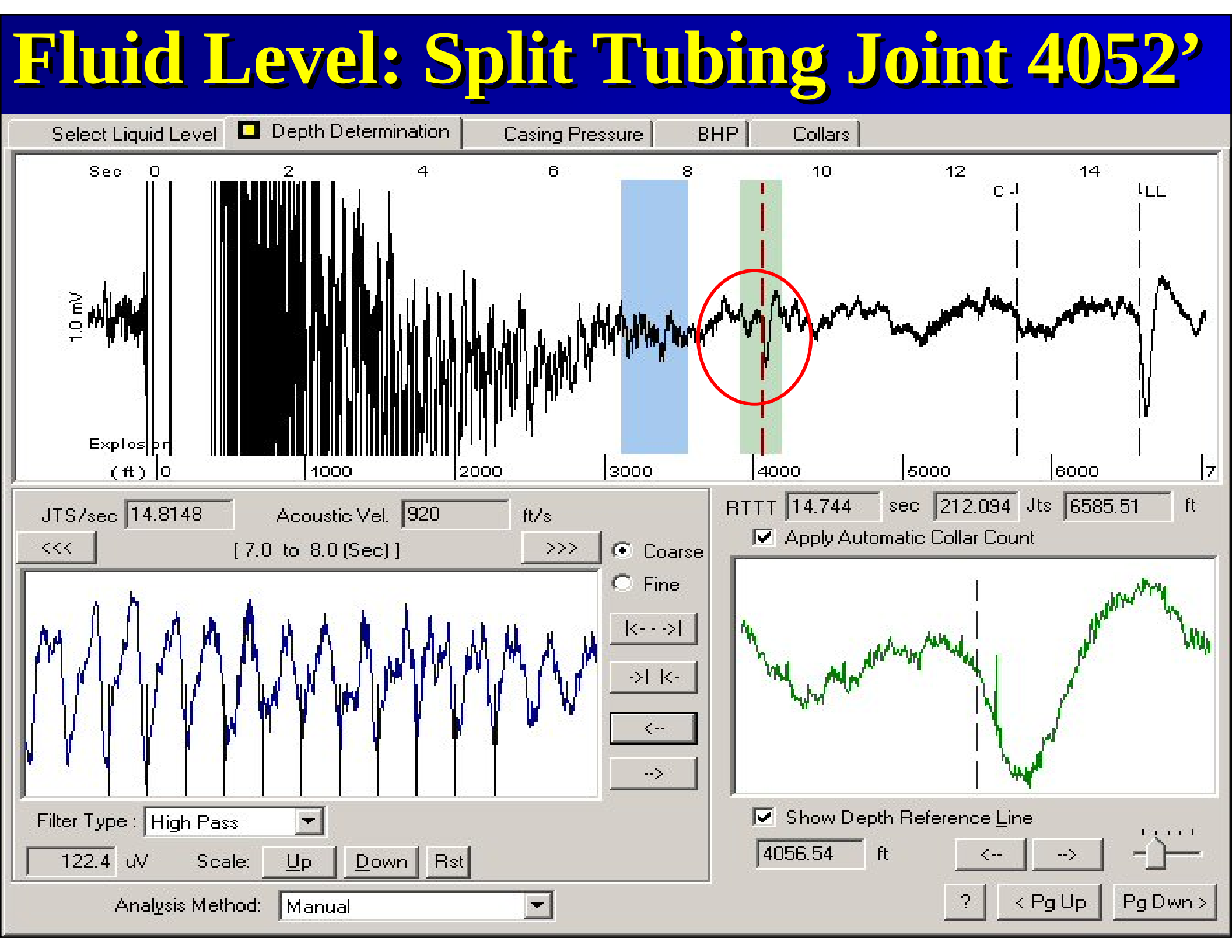
Effective Plunger Stroke

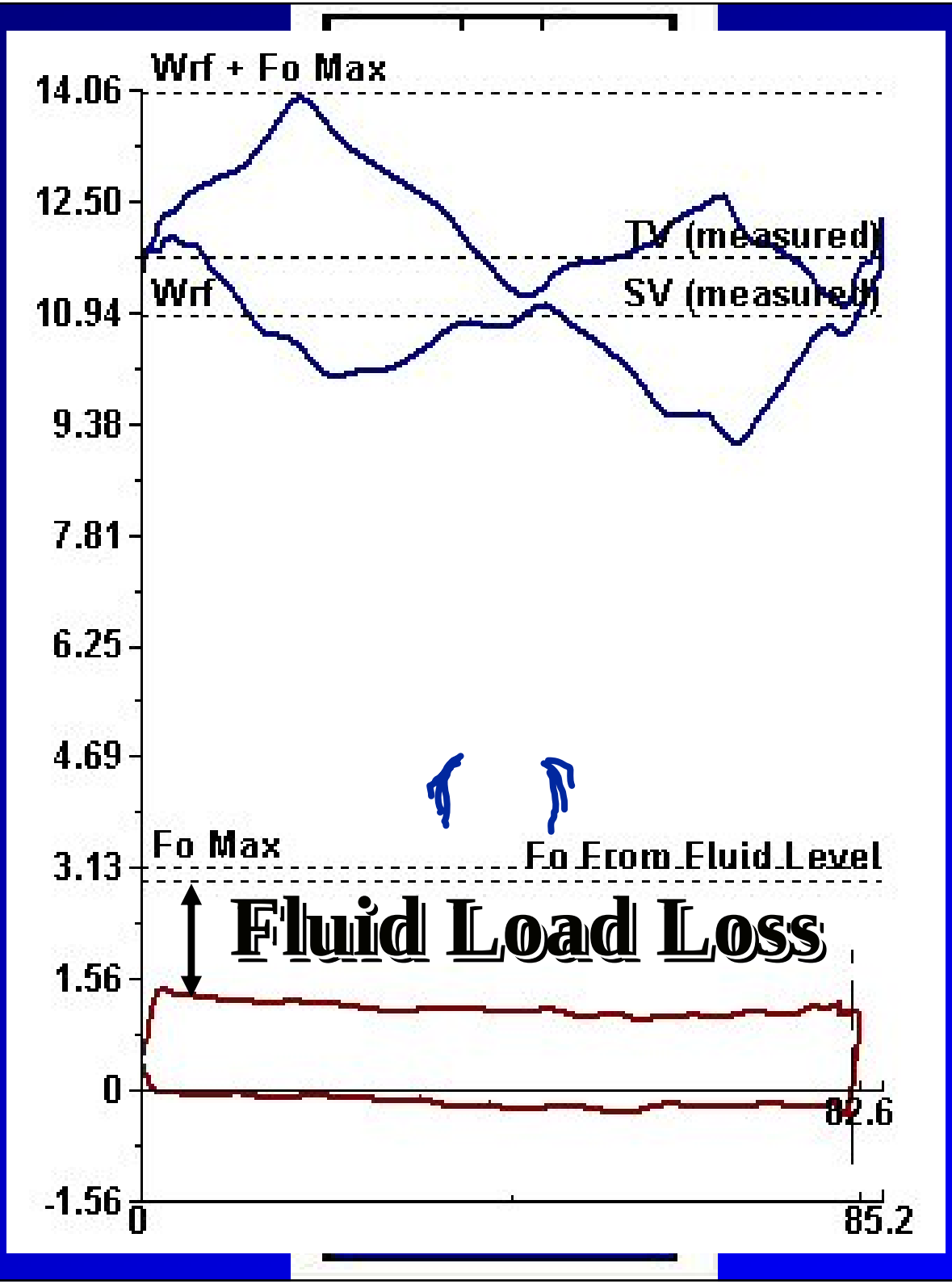
< --- Left | Right --- > | Approx. Best Pos.

99.12 % 78.2 in

Stroke 1 ? < Pg Up Pg Dwn >

Fluid Level: Split Tubing Joint 4052’



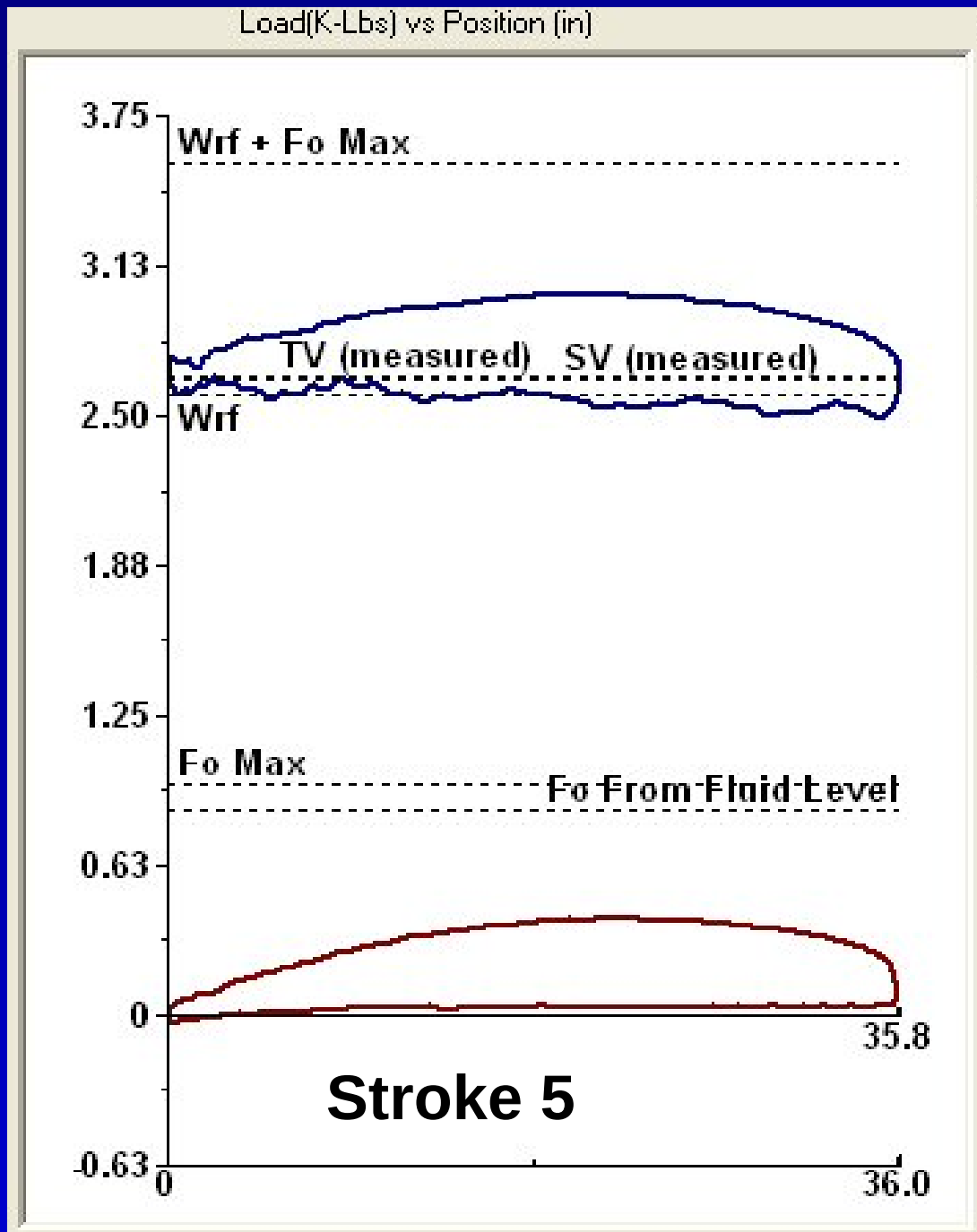


Fluid Load Loss reflects a surface dynamometer card when actual fluid load is less than the pre-calculated fluid load. This can be caused by a tubing or pump leak, a worn out pump, leaky valves or a high tubing-casing annulus fluid level when the net lift, H, has arbitrarily assumed or established at pump depth, L.

Split Tubing Joint	4000’
Fluid Level	6583’
Pump Depth	6975’
Net Lift	**2583’**

Hole in Tubing is detected using dynamometer, because Net Lift shown by the pump card Fo is much less that Fo required by fluid level and full pump card’s valves are OK .

Is the ball/seat Or plunger/ barrel worn out?



HT491

PPRL	3005	PPUMPL	403
MPRL	2490	MPUMPL	-35

Calculated Fluid Load Max	964	lb
Polished Rod Power	0.2	HP
Polished Rod / Motor Eff.		%
Strokes Per Minute	7.17	
Pump Card HP	0.2	HP
Pump / Motor Eff.		%
Pump Displacement	29.9	BBL/D
Pump Intake Pressure...	744.7	psi (g)
Damp Up	0.02	
Damp Down	0.02	
Tubing Head Pressure	12.0	psi (g)

<< Reset

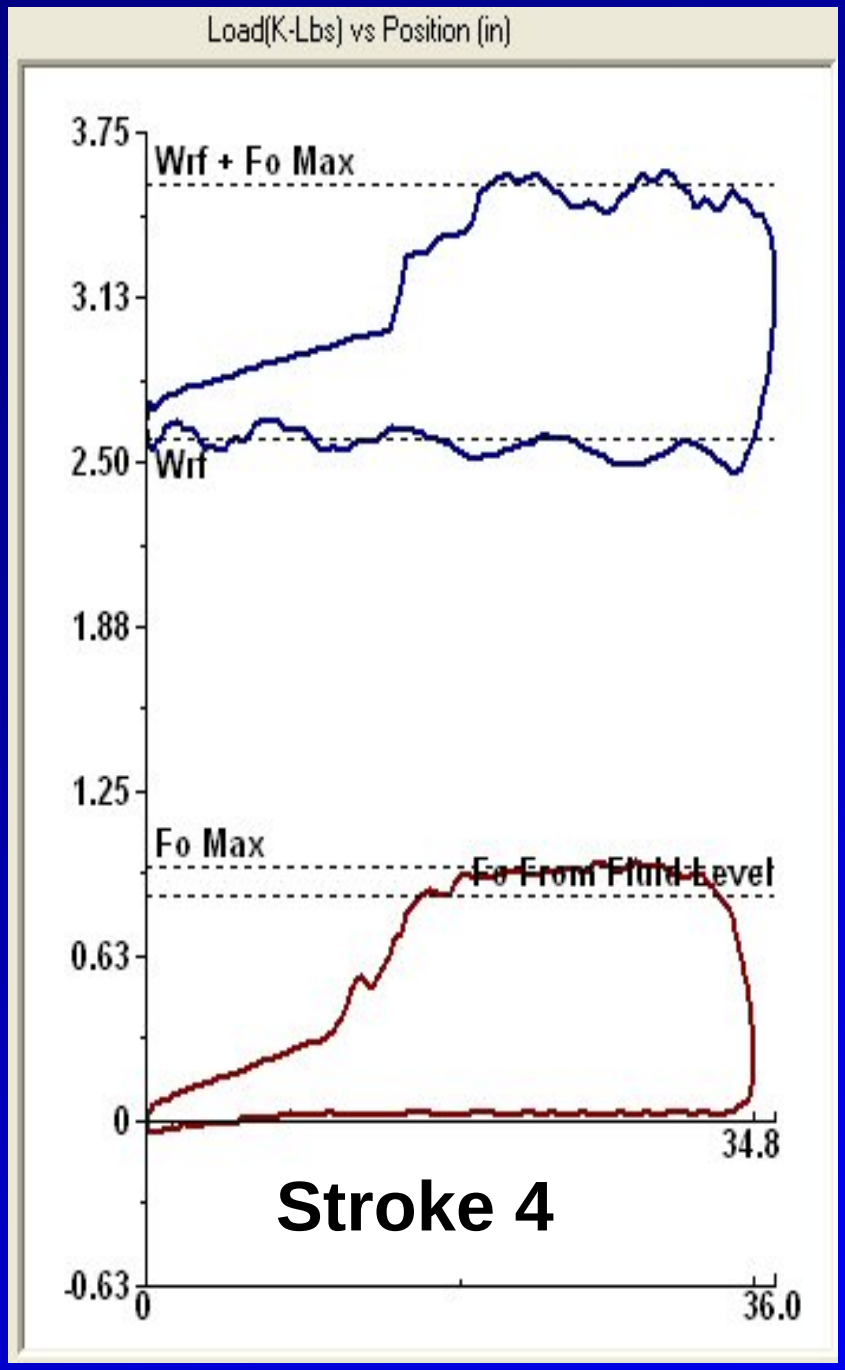
Effective Plunger Stroke

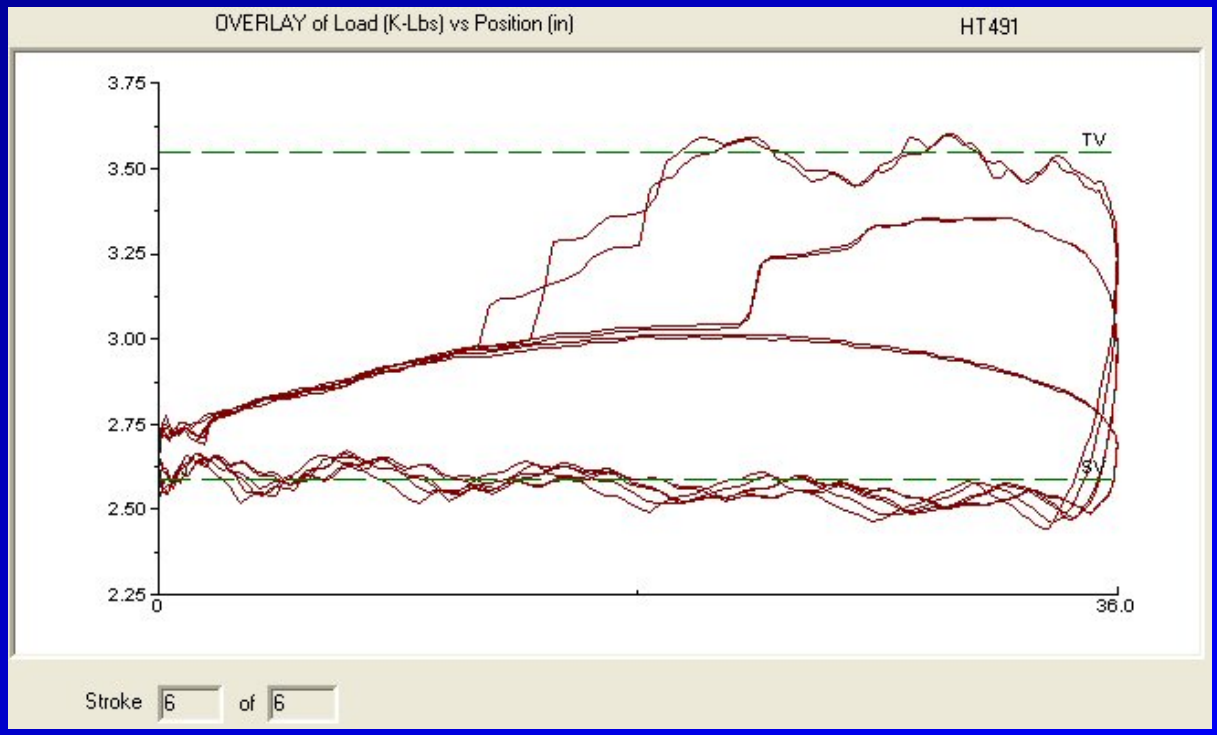
< --- Left | Right --- > | Approx. Best Pos.

99.65 % 35.7 in

Stroke 5 | ? | < Pg Up | Pg Dwn >

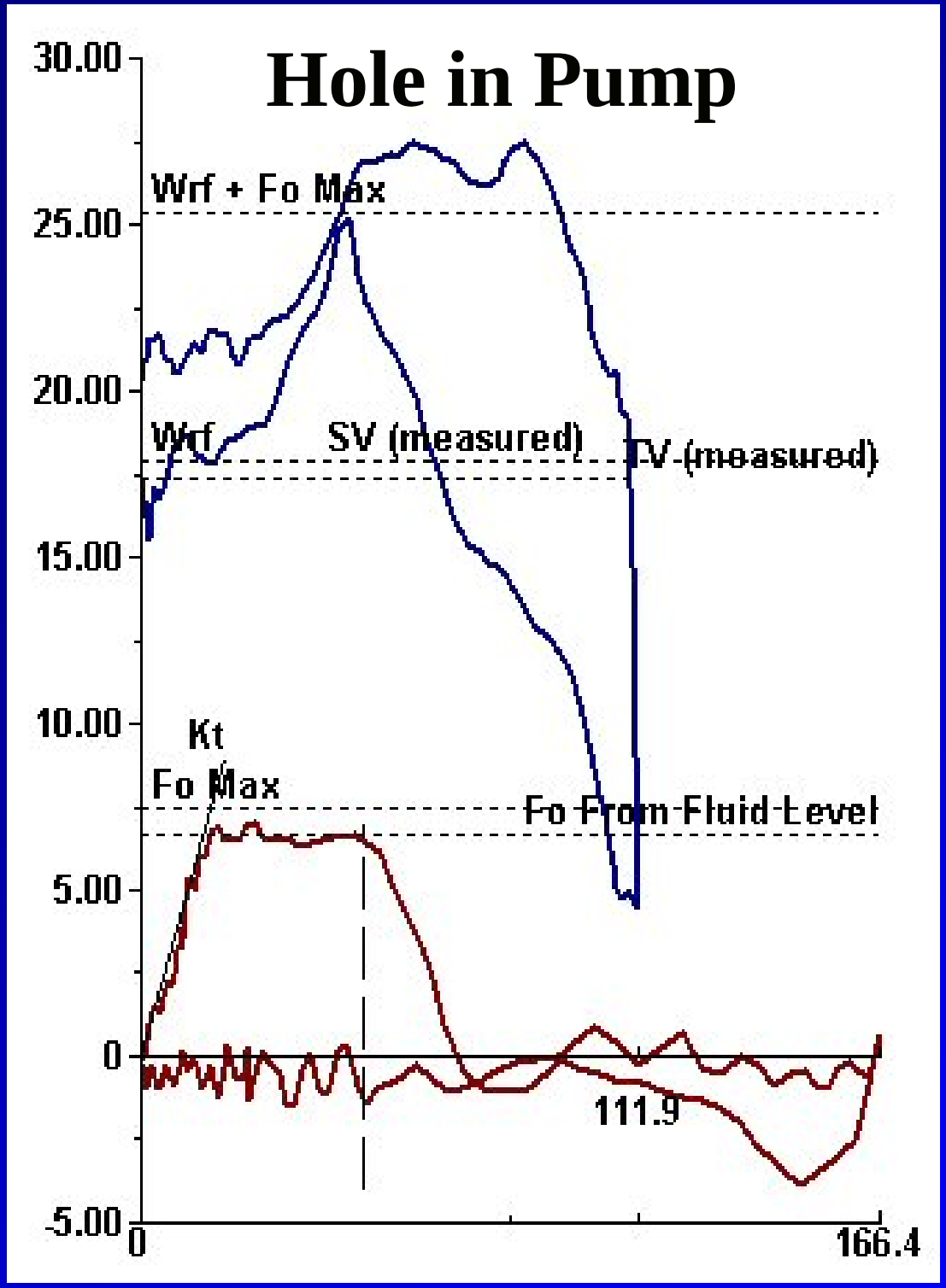
NO, Damaged TV Ball and seat.





Overlay of many Dynamometer Cards shows each stroke is different.

Worn pump plunger/barrel cards usually overlay.

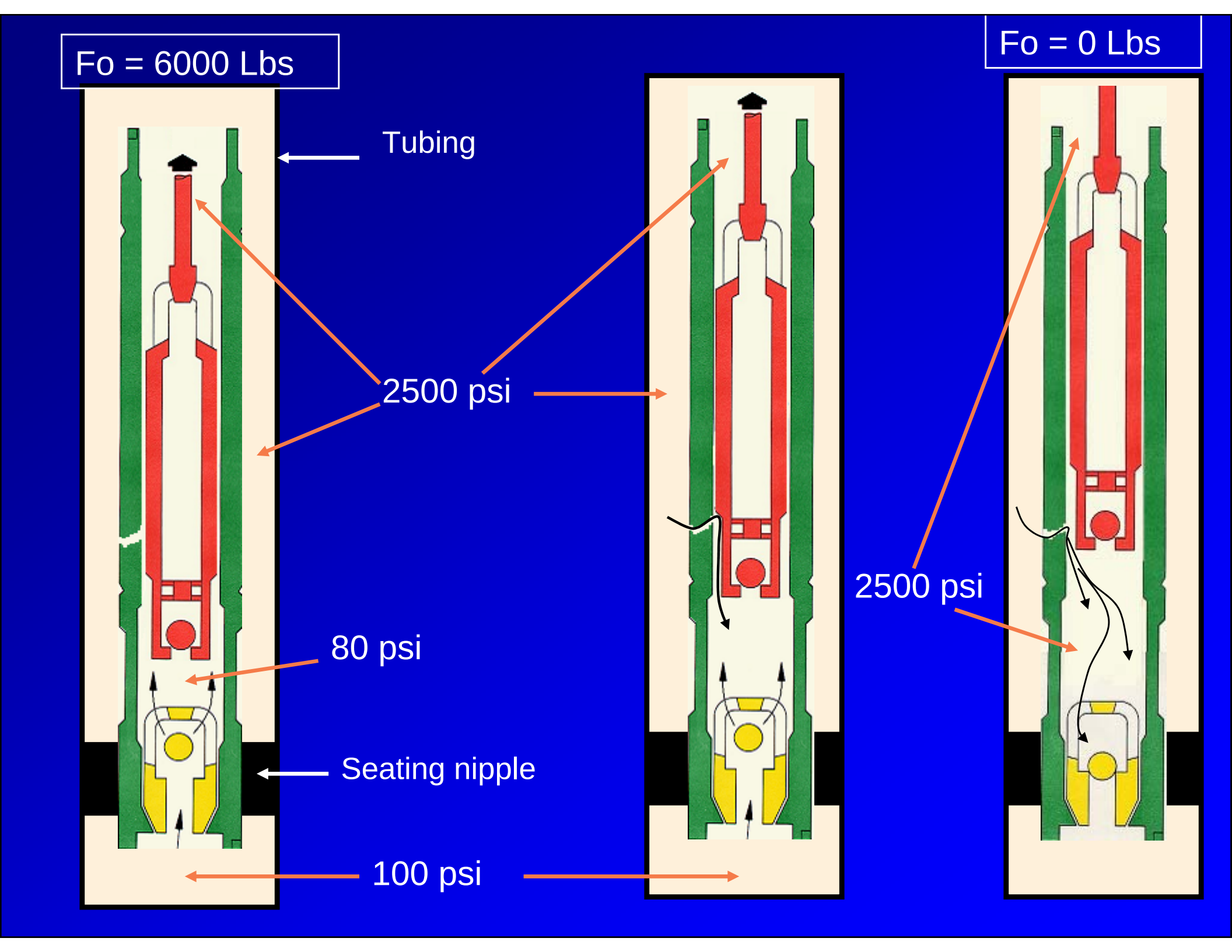


Well has a bottom hold down pump and the tubing anchor is not set. The hole in the pump barrel is about 56 inches from bottom of the stroke.

On the upstroke the fluid load is suddenly lost, which causes a much longer downhole stroke (over travel). When the bottom of the plunger is lifted past the hole, then the tubing pressure leaks between the outside of the pump barrel and the inside of the tubing.

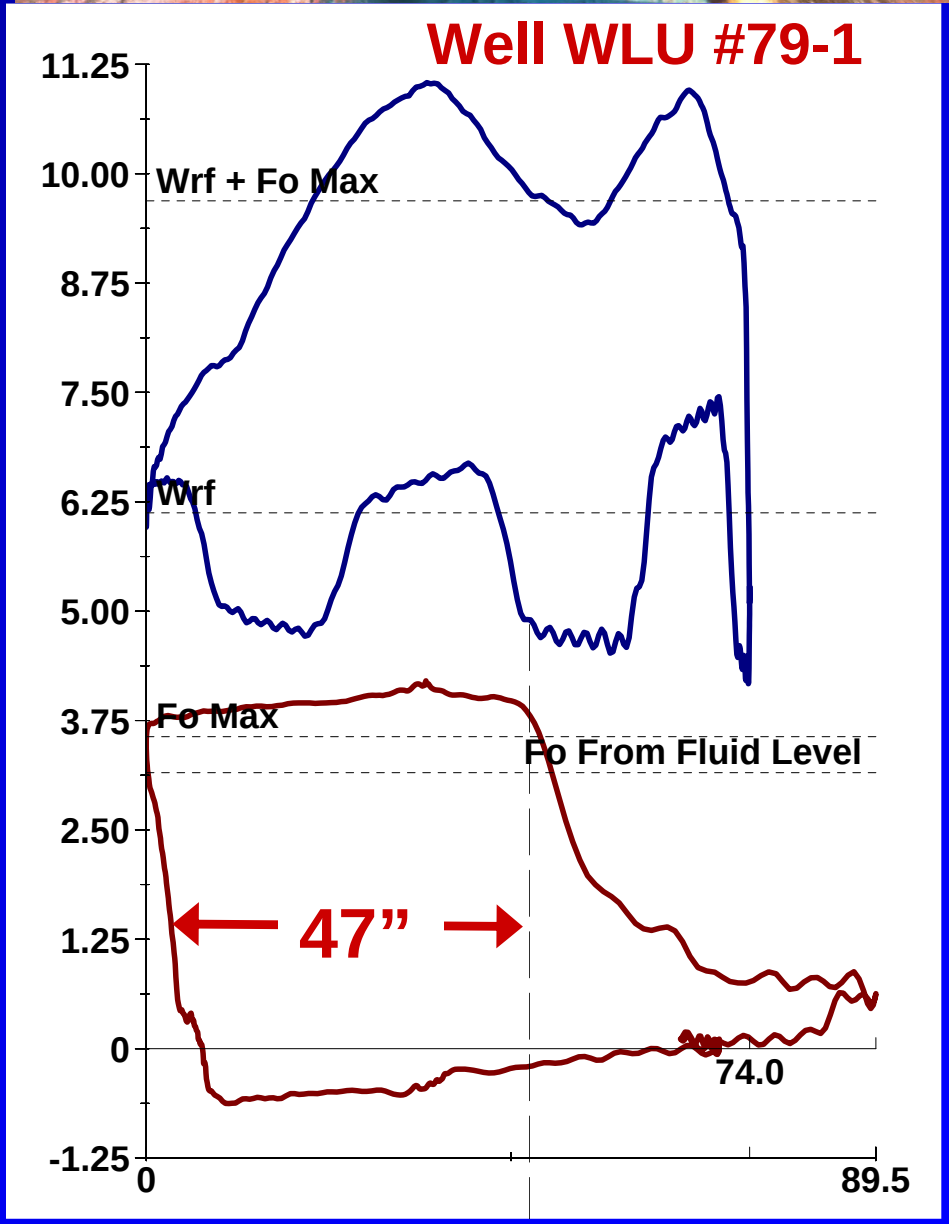
The pumping unit wobbled real bad when on the downstroke, often an indicator of deep parted rods.

TV and SV load checks equal, if stopped early on upstroke the fluid load would have been measured. Don't always stop in same place for valve checks when trying to trouble-shoot a problem.


Fo = 6000 Lbs
Tubing
2500 psi
80 psi
Seating nipple
100 psi
Fo = 0 Lbs
2500 psi

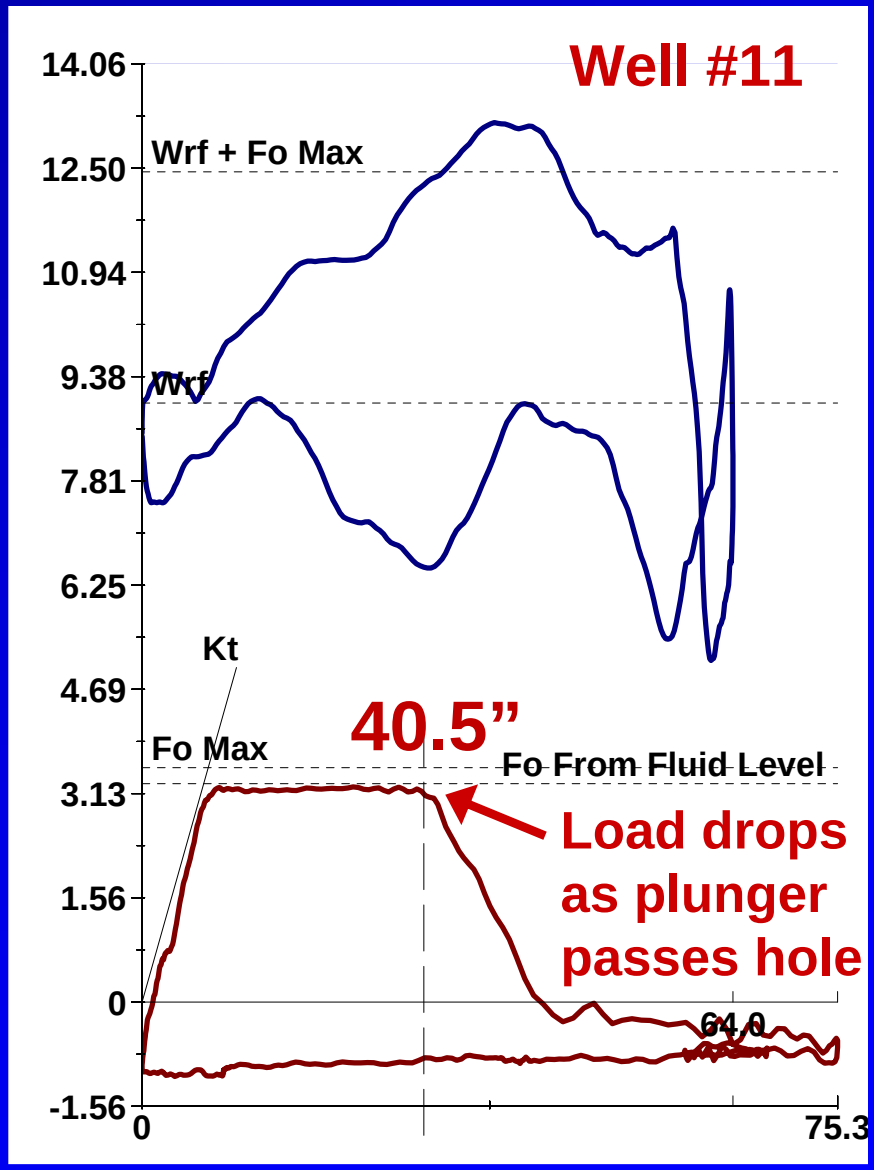
Hole in Pump
Split Barrel @ 4.8 Ft

- Pump Spaced 1 Ft off bottom
- Split Barrel From Fluid Pound
- Pound Damages and Weakens Pump Barrel.

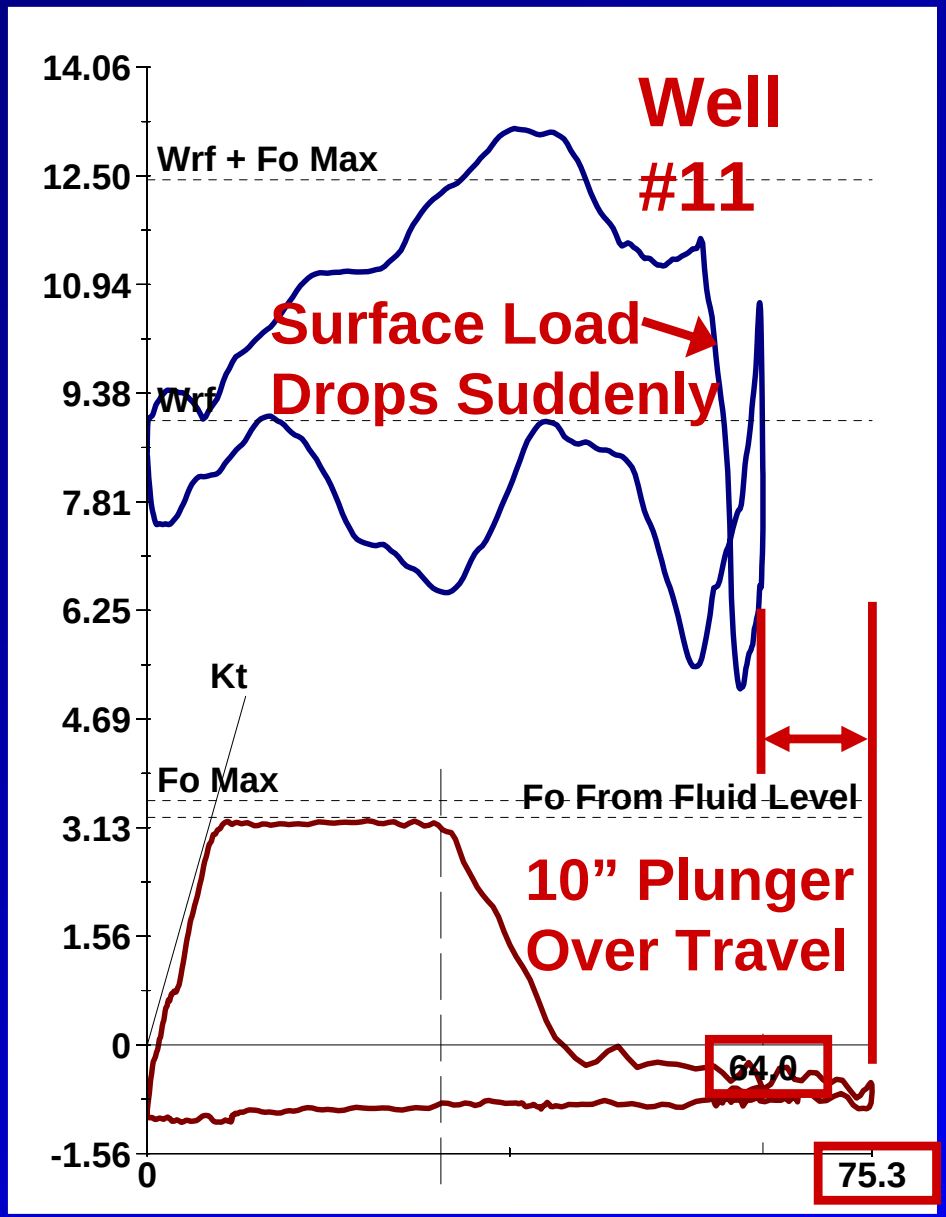


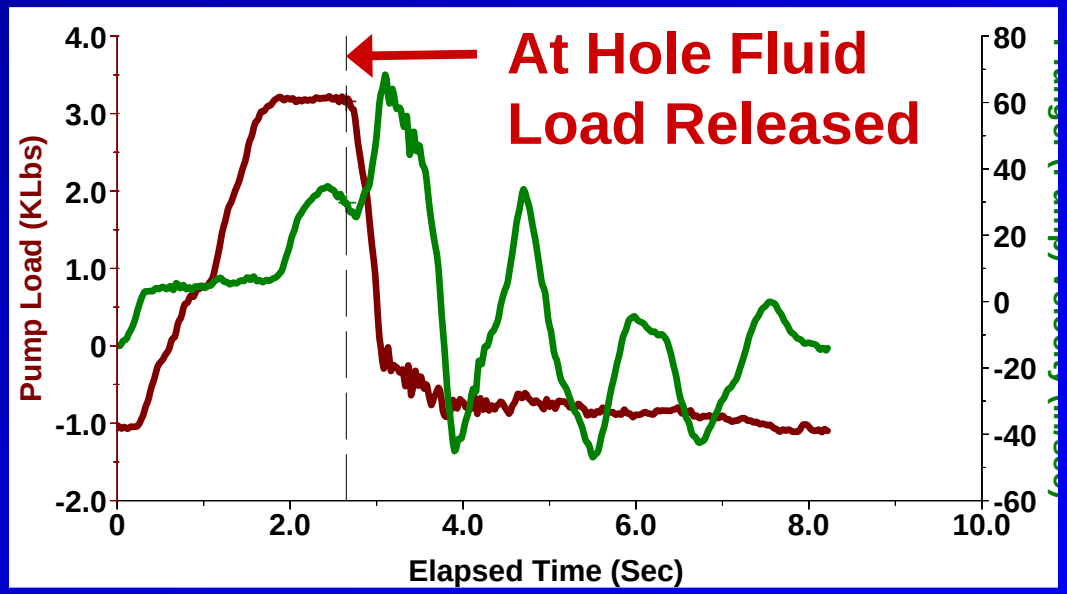
Hole in Pump Barrel 40.5 Inches From Bottom

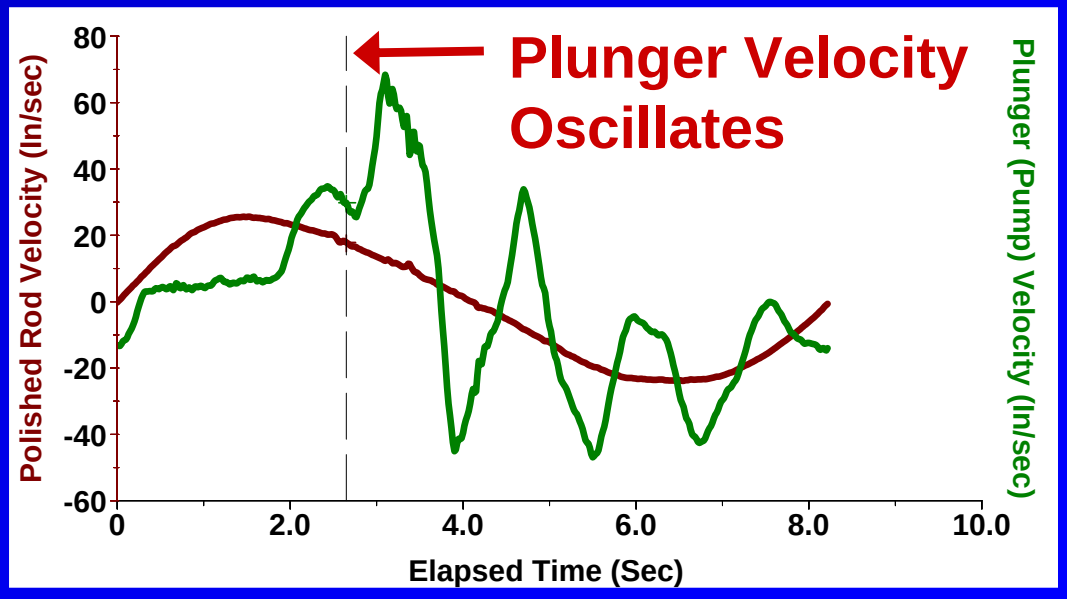
Hole in pump barrel due to corrosion

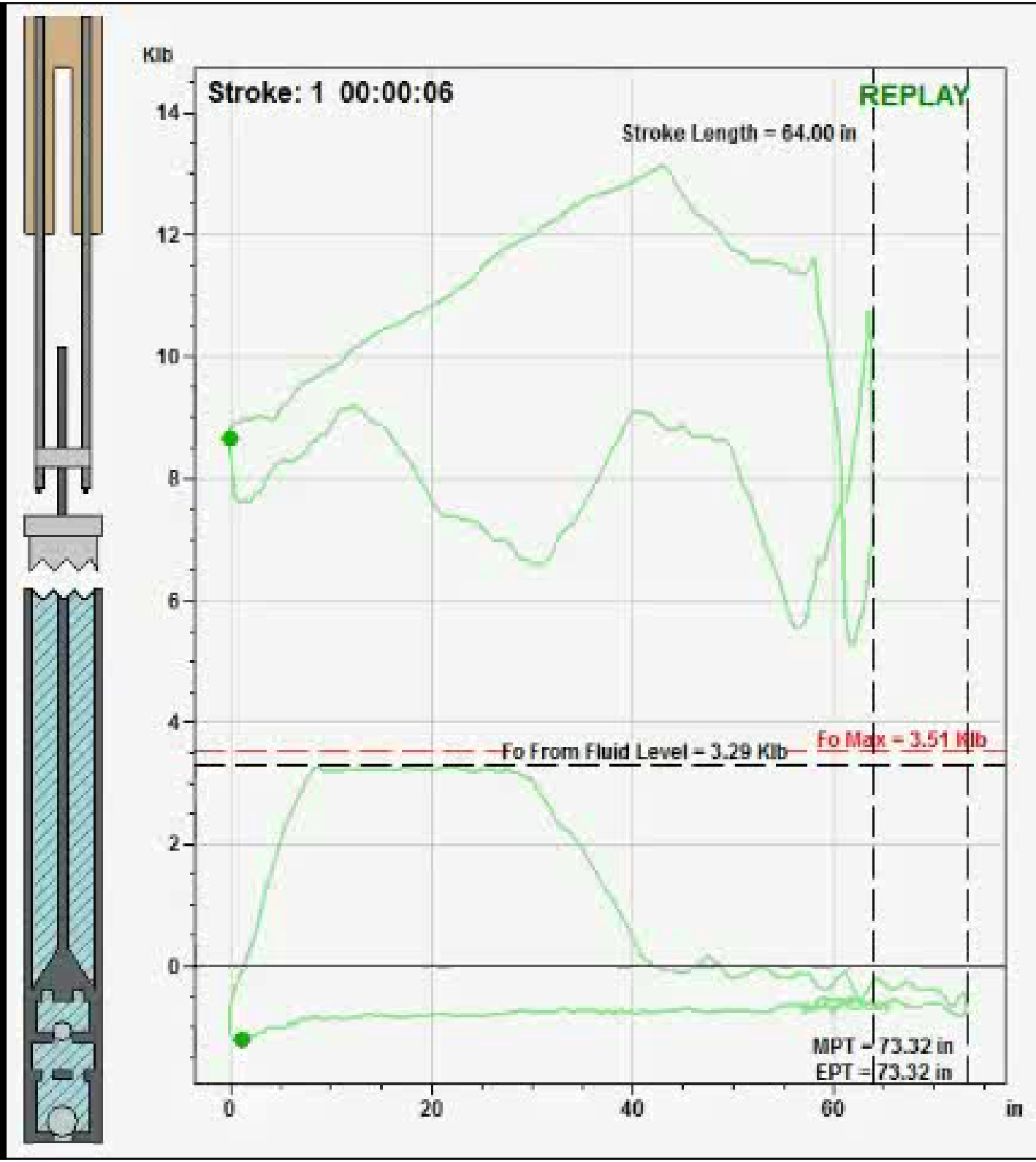


When the Plunger Goes Past the Hole ~ Fluid Load Released and the Plunger Takes Off



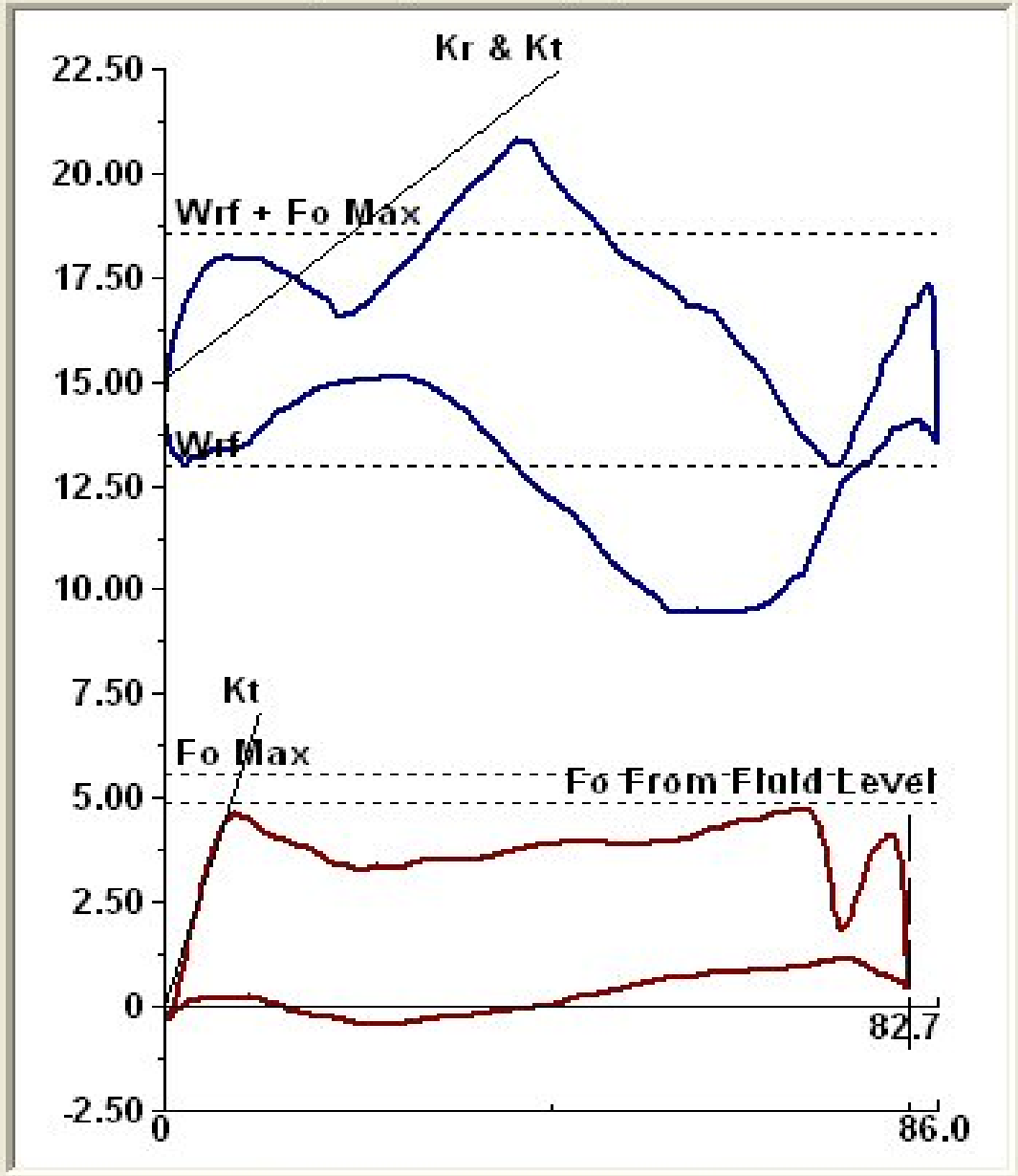





Klb
Stroke: 1 00:00:06
REPLAY
Stroke Length = 64.00 in
14
12
10
8
6
4
2
0
Fo From Fluid Level = 3.29 Klb
Fo Max = 3.51 Klb
MPT = 73.32 in
EPT = 73.32 in
0
20
40
60
in

Worn Barrel

Data was collected on this well because the production to the tank had fallen off.



PRT926

PPRL	20821	PPUMPL	4727
MPRL	9451	MPUMPL	-468

Calculated Fluid Load Max	5574	lb
Polished Rod Power	11.0	HP
Polished Rod / Motor Eff.		%
Strokes Per Minute	10.98	
Pump Card HP	7.8	HP
Pump / Motor Eff.		%
Pump Displacement	238.0	BBL/D
Pump Intake Pressure...	832.9	psi (g)
Damp Up	0.05	
Damp Down	0.05	
Tubing Head Pressure	100.0	psi (g)

<< Reset

Effective Plunger Stroke

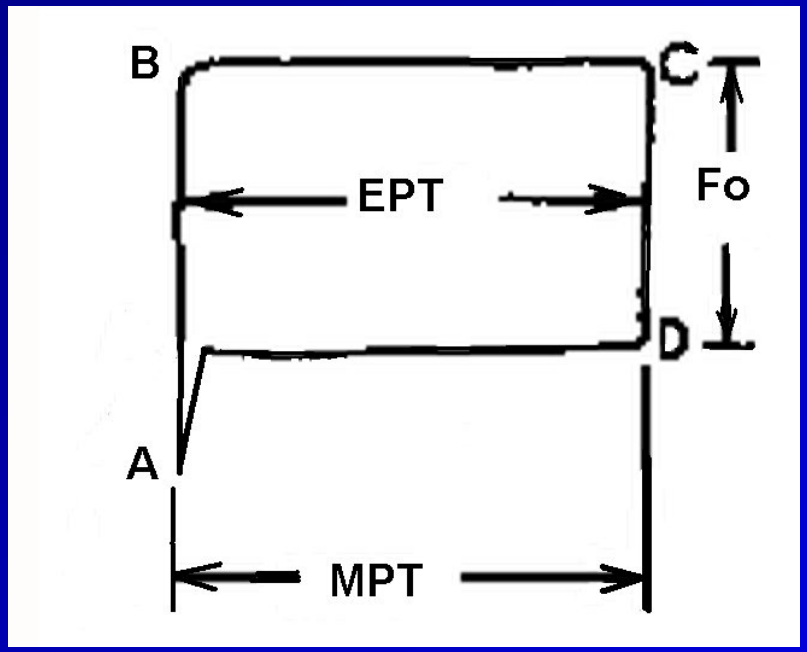
< --- Left | Right --- > | Approx. Best Pos.

100.00 % 82.7 in

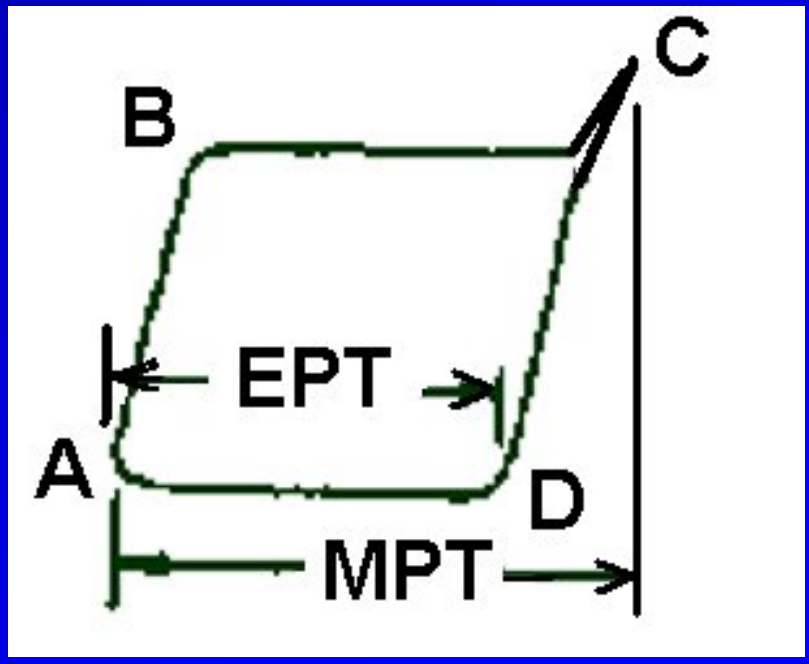
Stroke 1 ? < Pg Up Pg Dwn >

Synthetic Pump Cards: Improperly Spaced Plunger

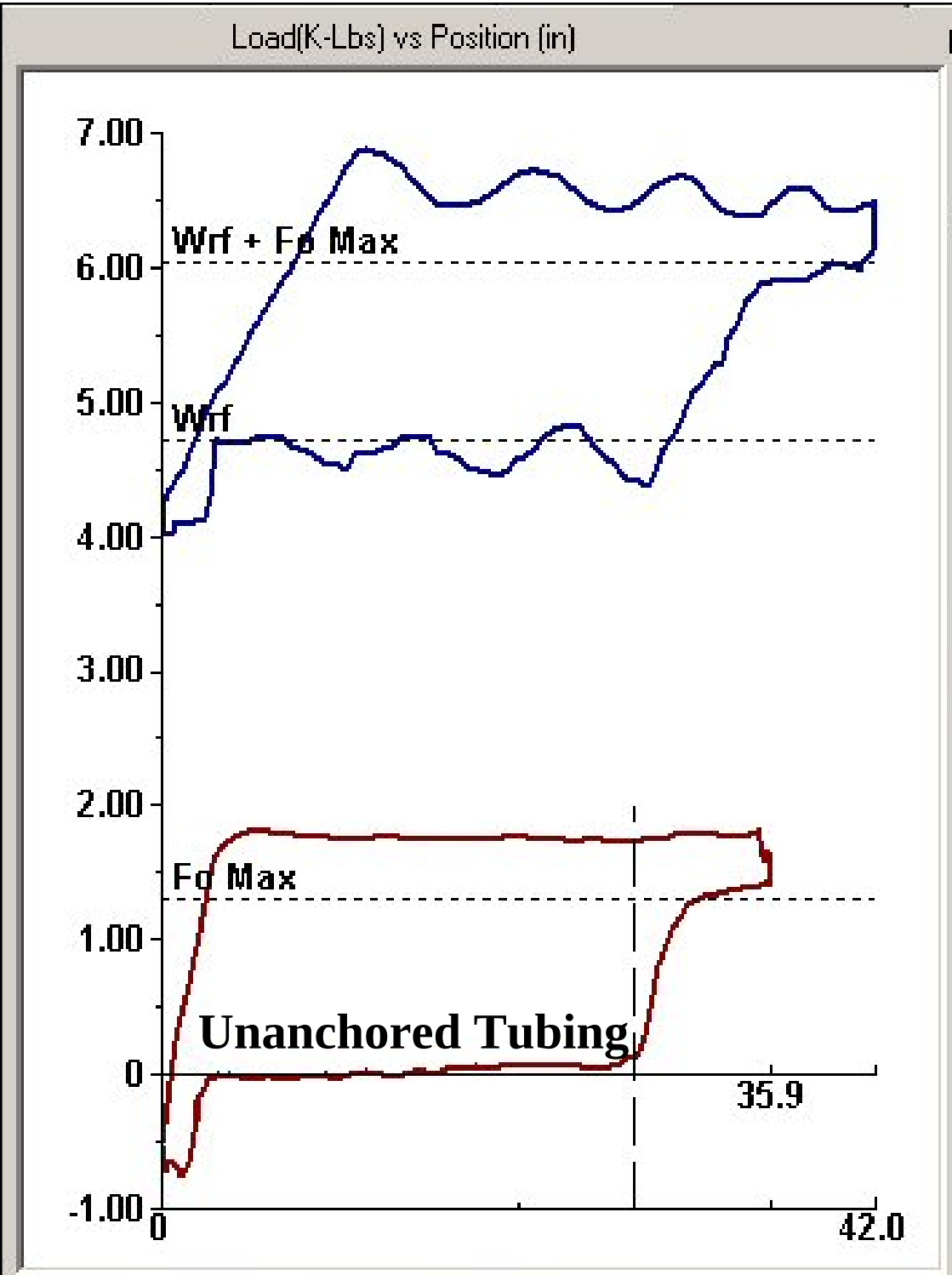
Tubing anchored, EPT=MPT.



Unanchored tubing, EPT<MPT



Pump is tapping at bottom of stroke(left). Pump is tapping at the top of stroke(right). Damage to pump, rods, and tubing is likely.



HLT024

PPRL 6878 PPUMPL 1820

MPRL 4004 MPUMPL -753

Calculated Fluid Load Max	1313	lb
Polished Rod Power	0.8	HP
Polished Rod / Motor Eff.		%
Strokes Per Minute	5.06	
Pump Card HP	0.7	HP
Pump / Motor Eff.		%
Pump Displacement	20.7	BBL/D
Pump Intake Pressure...	53.6	psi (g)
Damp Up	0.05	
Damp Down	0.05	
Tubing Head Pressure	60.0	psi (g)

<< Reset

Effective Plunger Stroke

< --- Left | Right --- > | Approx. Best Pos.

77.35 % 27.8 in

Stroke 1 ? < Pg Up Pg Dwn >

Kr 343 lb/in Kt 970 lb/in Dyna Card Options...

Severe Tag on Steel Rods