2006 International Sucker Rod Pumping Workshop

Trouble Shooting II

Houston, Texas

September 14 - 15, 2006

Lynn Rowlan

ECHOMETER

What Should be Known in Order to Trouble Shoot a Well?

- Recent and/or Representative Well Test
- Pump Capacity   (or, Pump Card)
- Producing BHP & Static BHP
- Artificial Lift System Description
- Energy Efficiency
- Wellbore description
- Artificial Lift System Design
- Fluid Properties
- Past History

Collect/Analyze Well Data and Answer Questions TO TROUBLE SHOOT WELL:

From Acoustic Surveys:

Does liquid exist above the pump? At what depth is the top of the liquid column?

Does the liquid in the casing annulus restrict production from the well?

What is the maximum production rate available from the well?

From Dynamometer Surveys:

Is the well pumped off? What is the pump intake pressure? What is the pump fillage?

Is the traveling valve or standing valve leaking? What is the pump displacement?

What is the effective pump plunger travel? What is the current pumping speed?

Are the maximum and minimum rod loads within allowable limits?

What is the polished r

Is the gearbox overlo

Is the unit properly ba

Is the downhole gas s

From Motor Power Surveys

What is the overall electrical efficiency of the pumping system?

Is the overall electrical efficiency above 50%?

What is the power consumption, $/month, $/BBL, and power demand, KW?

What is the motor current? Does the motor overheat?

neration?

From Predictive Dynamometer Design Programs:

Is the predicted dynamometer in agreement with accurately measured horseshoe dynamometer data?

Can the performance be improved by a change in pump size, polished rod stroke length, SPM, rod string con

it?

From Transient Pressure Surveys:

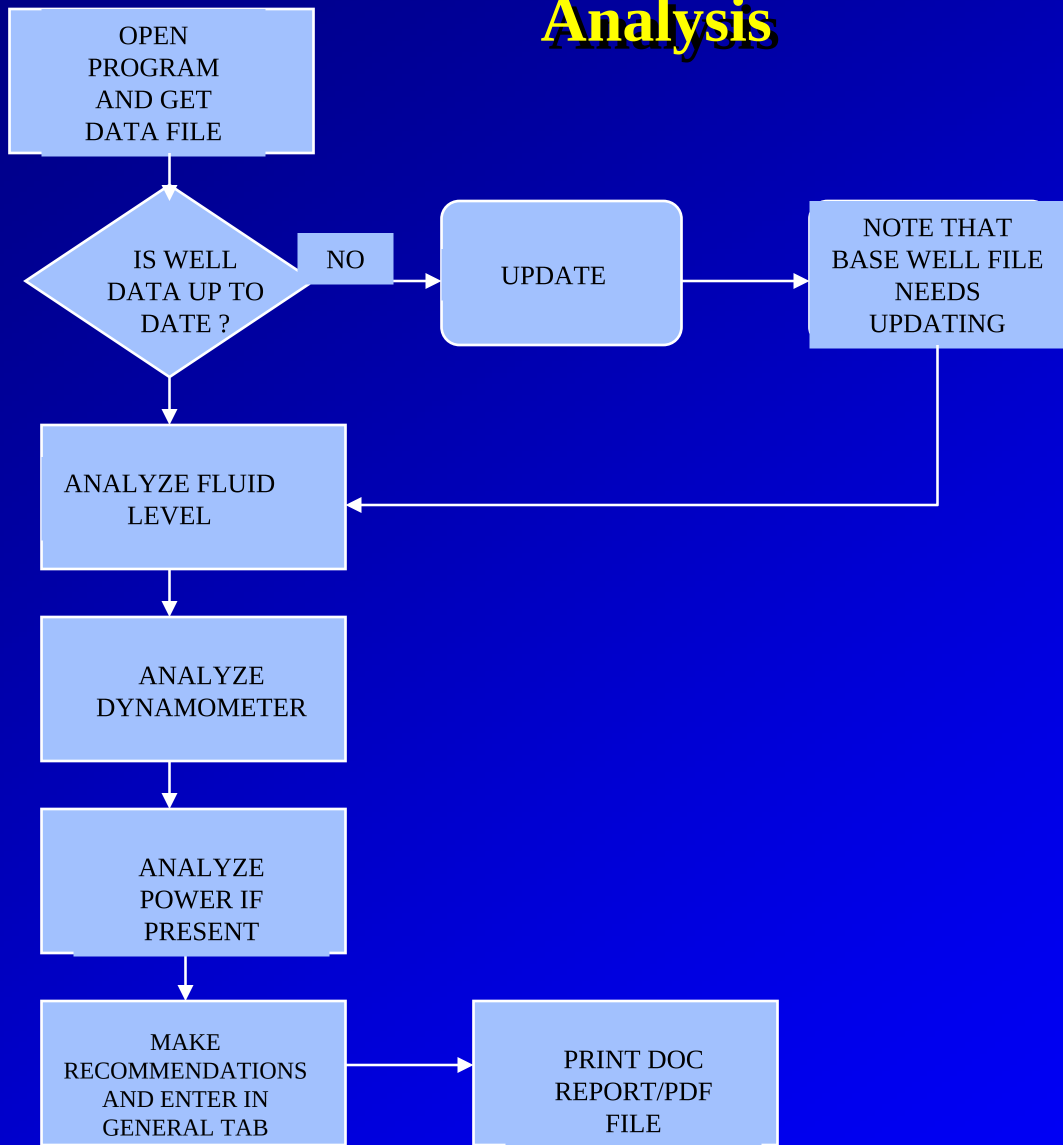
SPE 67273 Total Well Management II

What is the reservoir pressure? What is the producing bottom hole pressure?

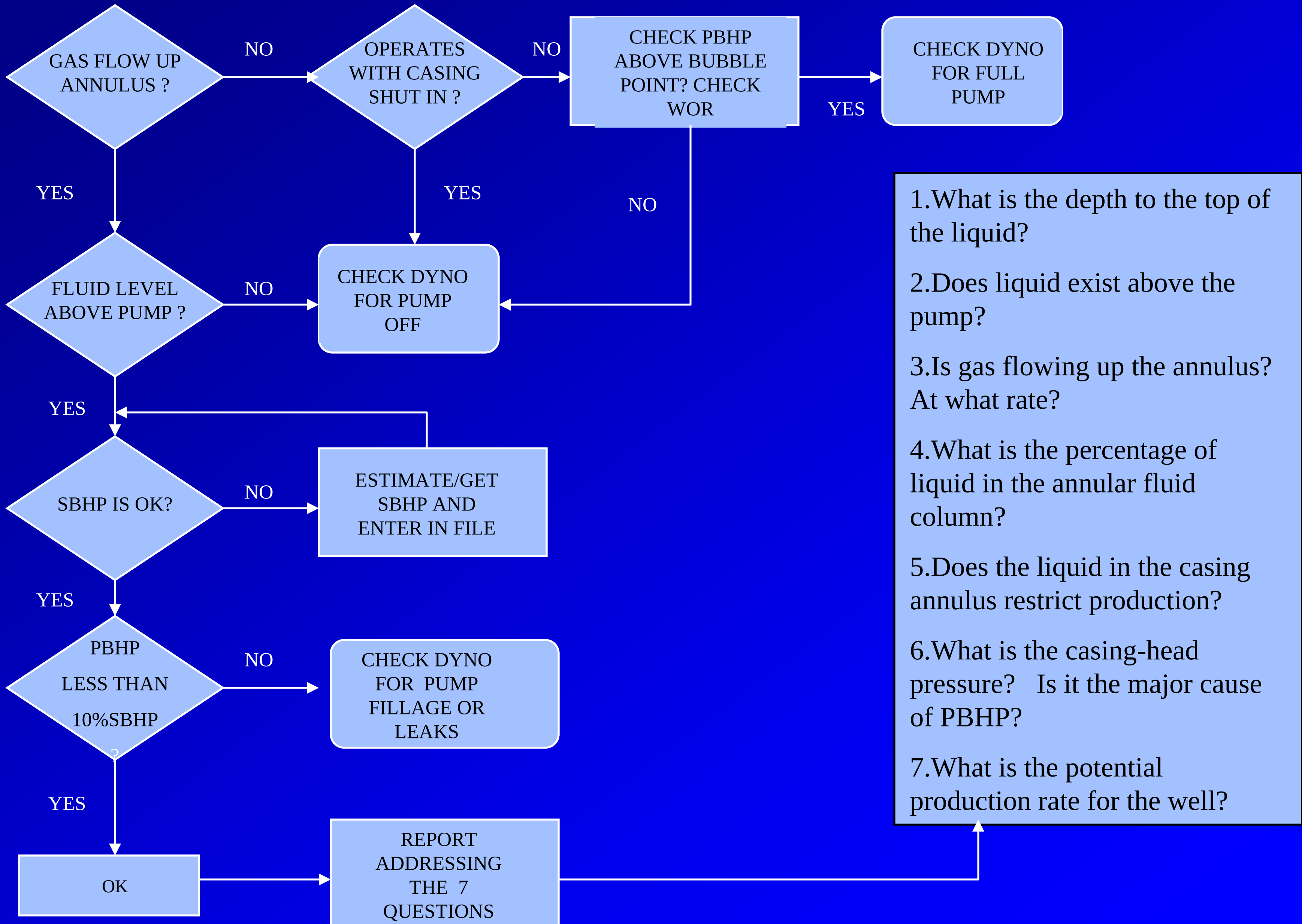
What is the liquid/gas annular afterflow when the well is shut in?

Is there any wellbore damage? Does the formation need treatment? Is the well fractured?

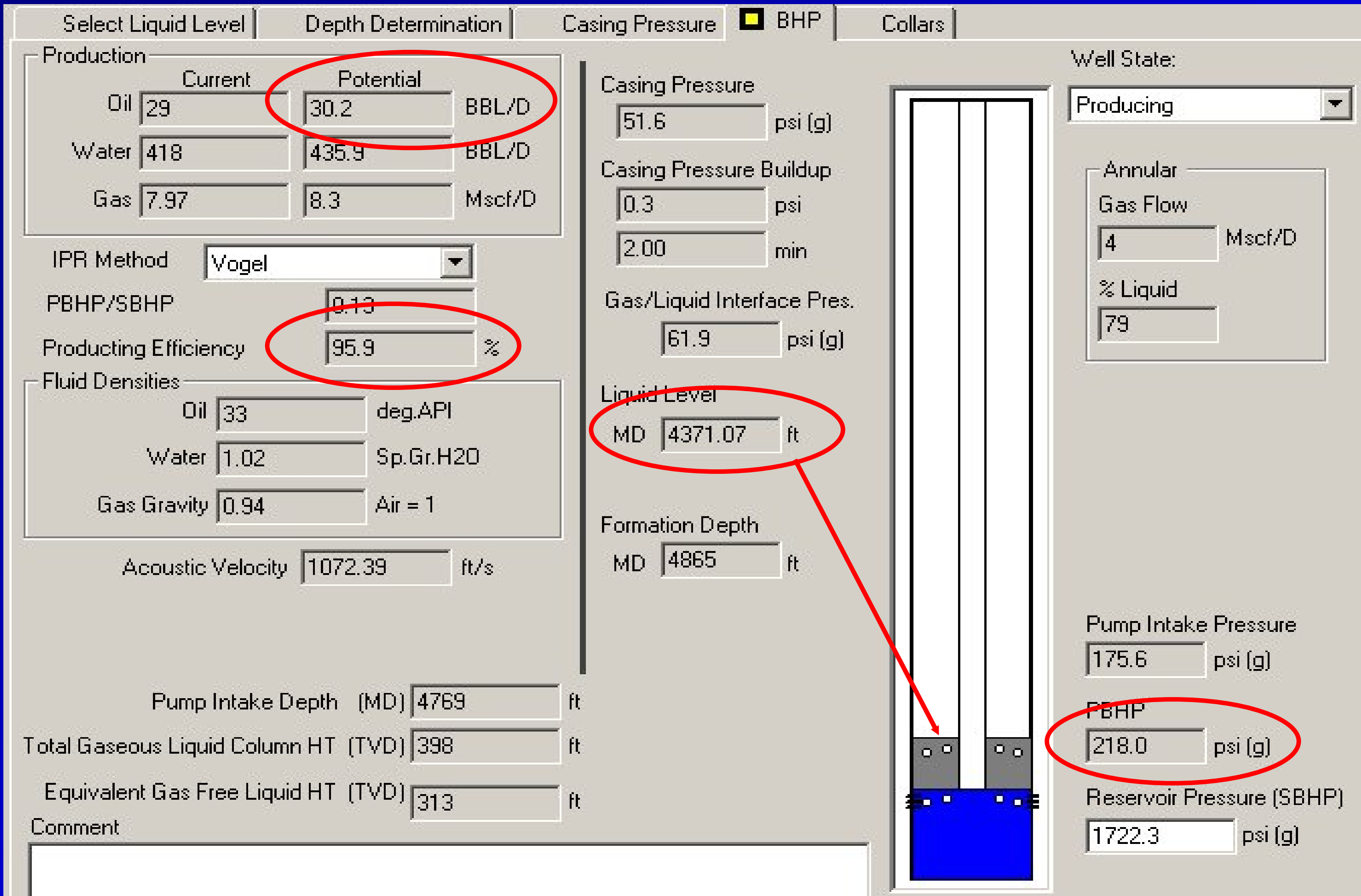
General Procedure for Well Analysis



General Analysis of Fluid Level Data



Acoustic Liquid Level Test Analysis



Design/Installation/Operation of Sucker Rod System

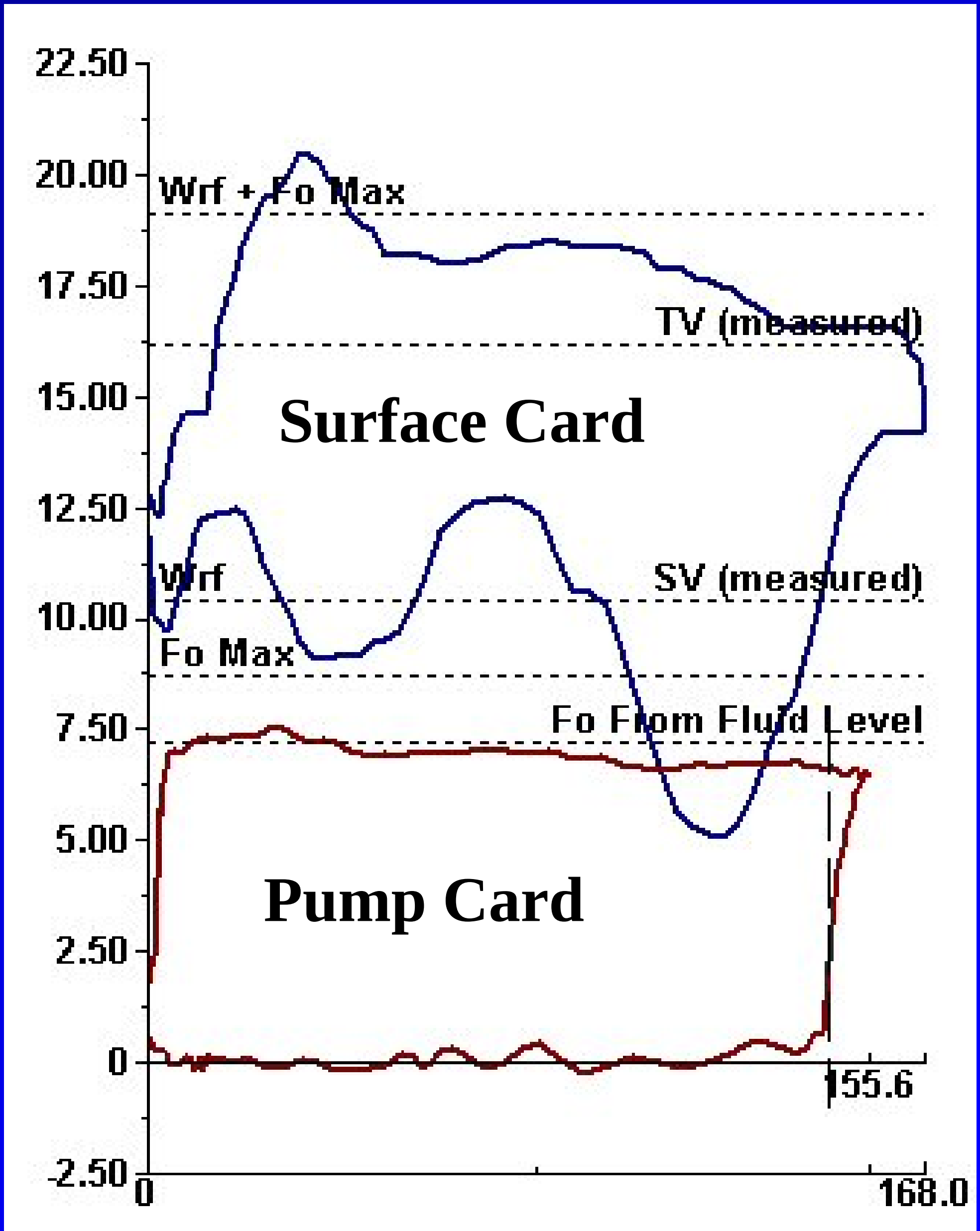
Equipment Installation Vs Operation & Maintenance

- To reduce operating cost attention must be paid to ease of maintenance and reliability.
- Maintenance and repair expenses for equipment may exceed initial cost.
- New Technology with changes in the equipment results in Early Time Failures.
- Severity of the environmental impacts operating conditions.
- Demand increases on Artificial Lift Equipment as well is drawn down.

Analyze w/ Surface & Pump Cards

1) **Surface Dynamometer cards for designing and diagnosing surface problems.**
   - Rod String
   - Pumping Unit
   - Pump Problems
   - Excessive Friction

2) **Pump card for analysis of downhole problems.**
   - Unanchored Tubing
   - Tubing Leak
   - Pump Problems
   - Pump Displacement



To Trouble Shoot a Well

1. Acquire Representative Well Info.
2. Use Process to Analyze
3. Several Indicators may be Used to Diagnose Problem
4. Identify and Troubleshoot Problems
5. Take Action to Fix Problem
6. Follow-up with Another Analysis

Problems of Assuring and Maintaining Long Equipment Life

- Well conditions change
- Original lift equipment design
- Control of quality during production
- Acceptance testing and inspection
- Pilot Projects and New Technology
- Changing Conditions require Lift Design modifications.

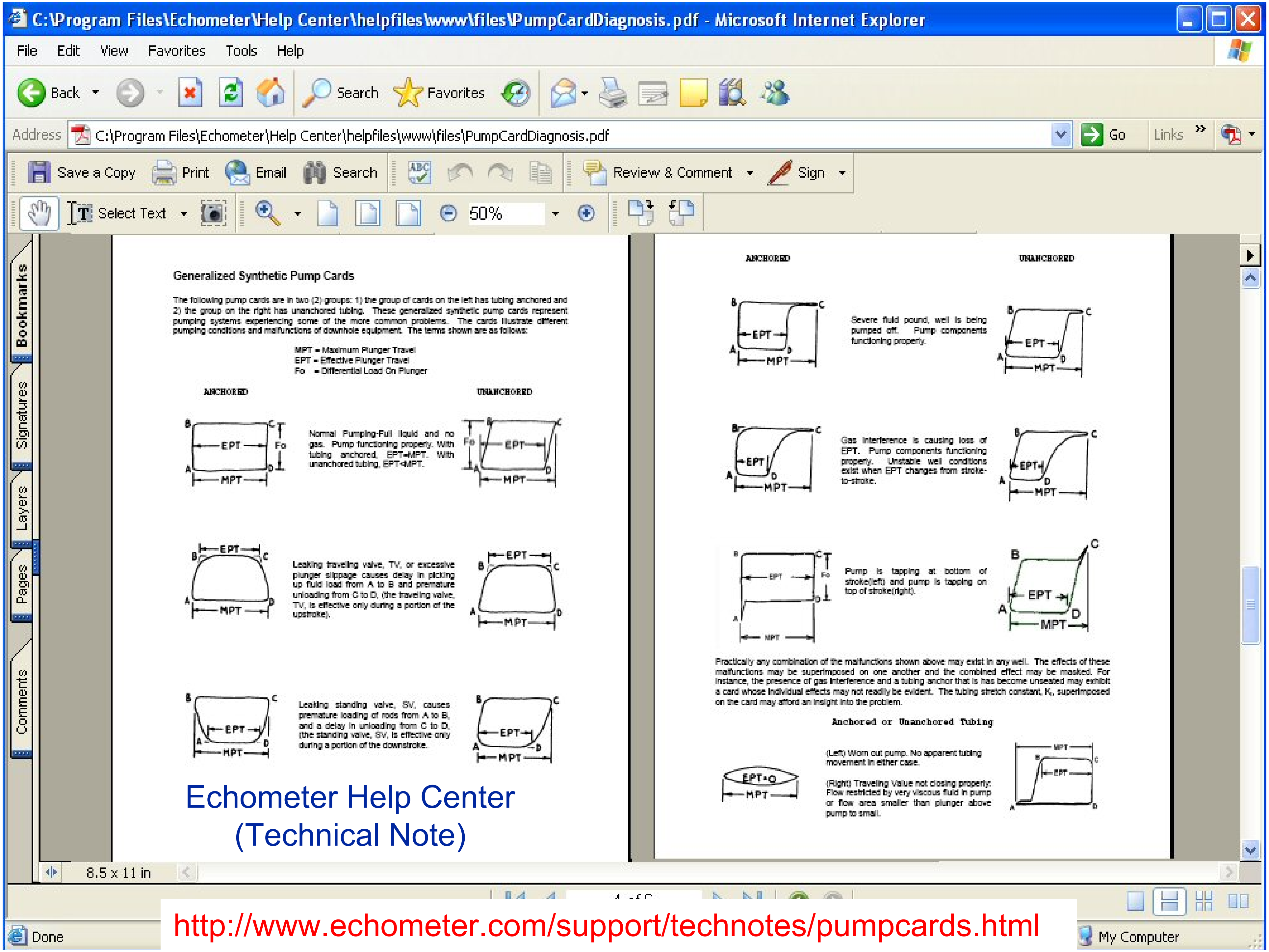
Common Techniques for Trouble Shooting

- Has Well's Production Changed?
- Is the Pumping Unit Running?
- Is there a noticeable Leak?
- Is fluid going into the tank?
- Has the Fluid Level Changed?
- Can the Pump Pressure up the Tubing?
- Does the Pressure Leak Off?

Physical Trouble Shooting Indicators

- Pressure Gages
- Hot Flow Lines
- Hot Polished Rod Load
- Sounds at the Well
- Equipment Vibrations
- Fluid on the Ground
- Ground Shakes

Shock Loads Shake the Ground



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_t, superimposed on the card may afford an insight into the problem.

Anchored or Unanchored Tubing

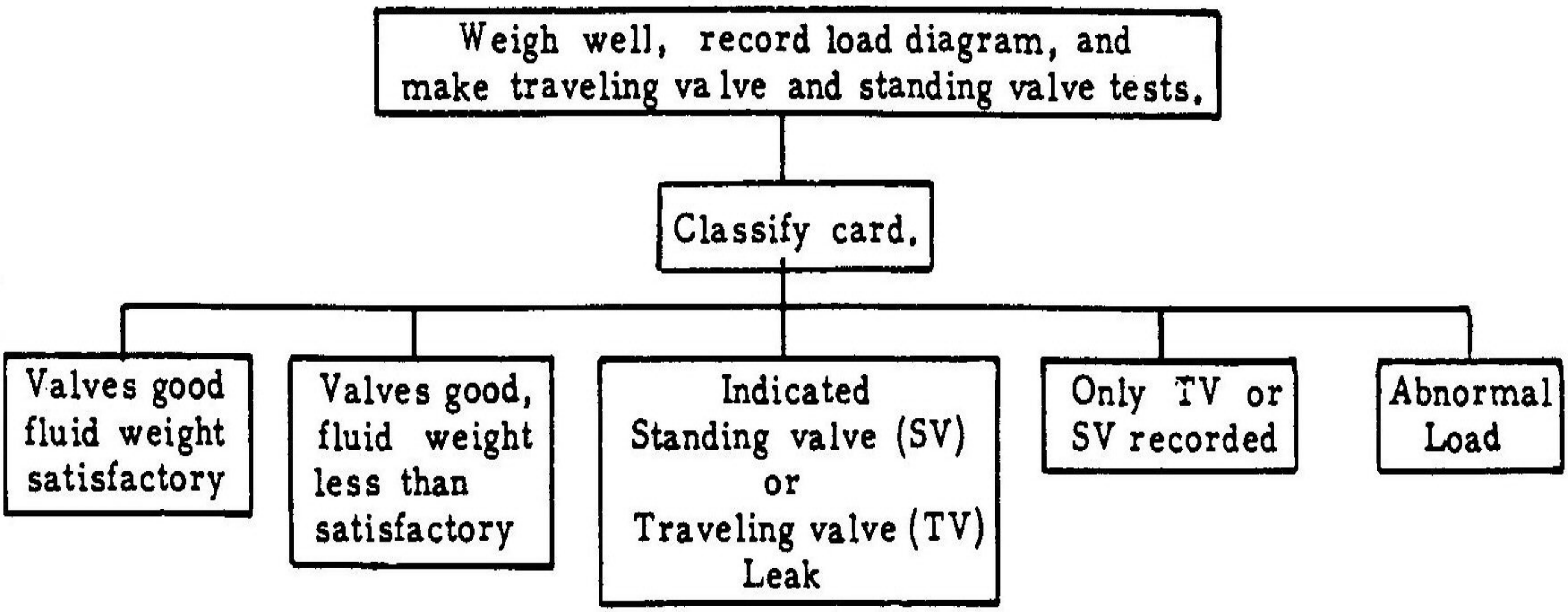
(Left) Worn out pump. No apparent tubing movement in either case.

(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)

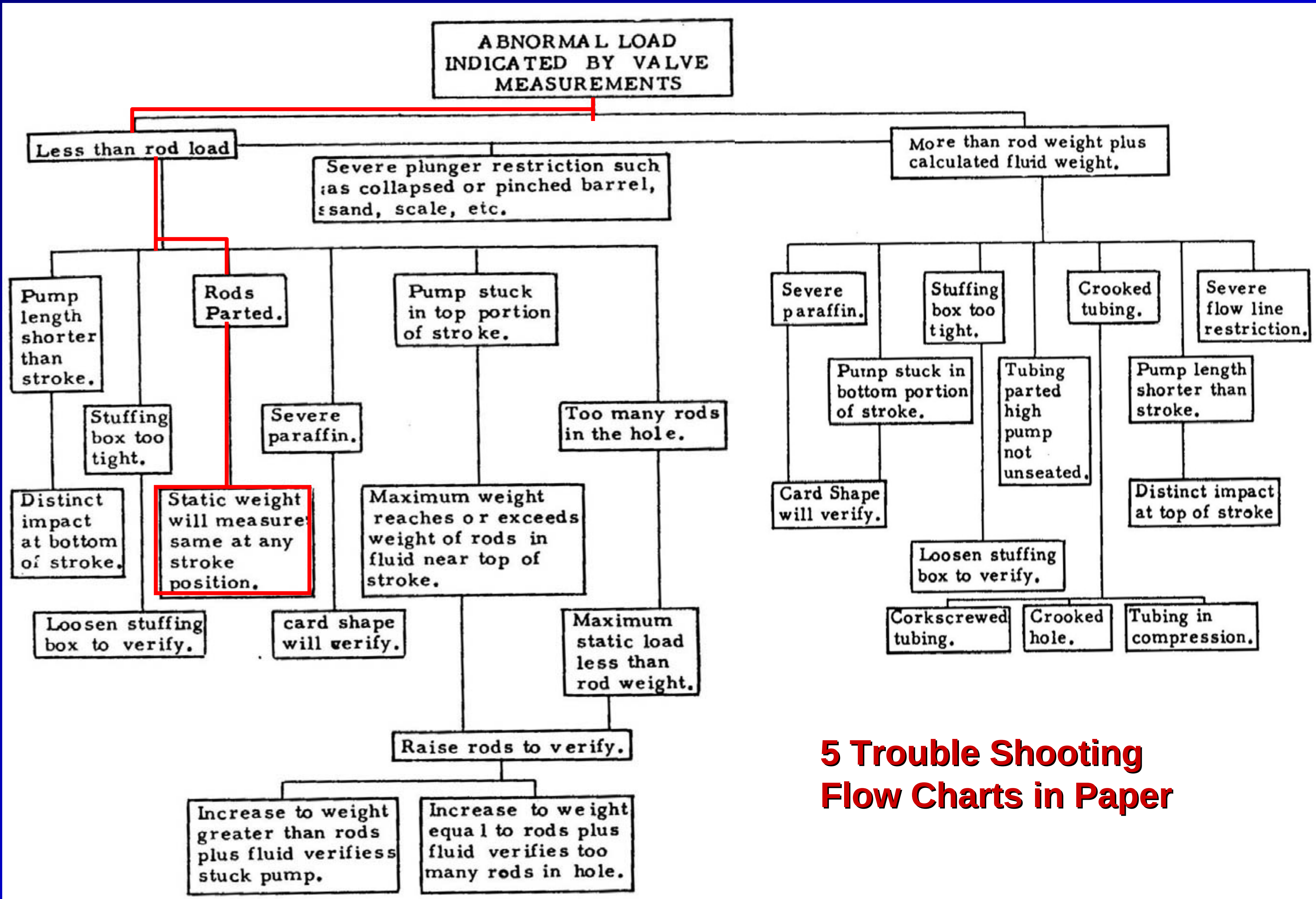
http://www.echometer.com/support/technotes/pumpcards.html

Dynamometer Testing for Trouble Shooting the Pumping Well Problem



From "Dynamometer Testing for Analyzing the Pumping Well Problem",

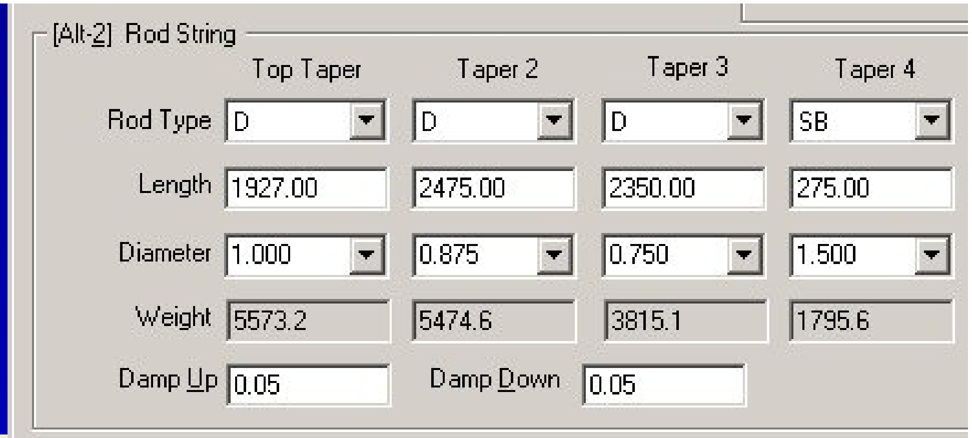
By C. J. MERRYMAN & D. K. LAWRENCE, SWPSC 1958



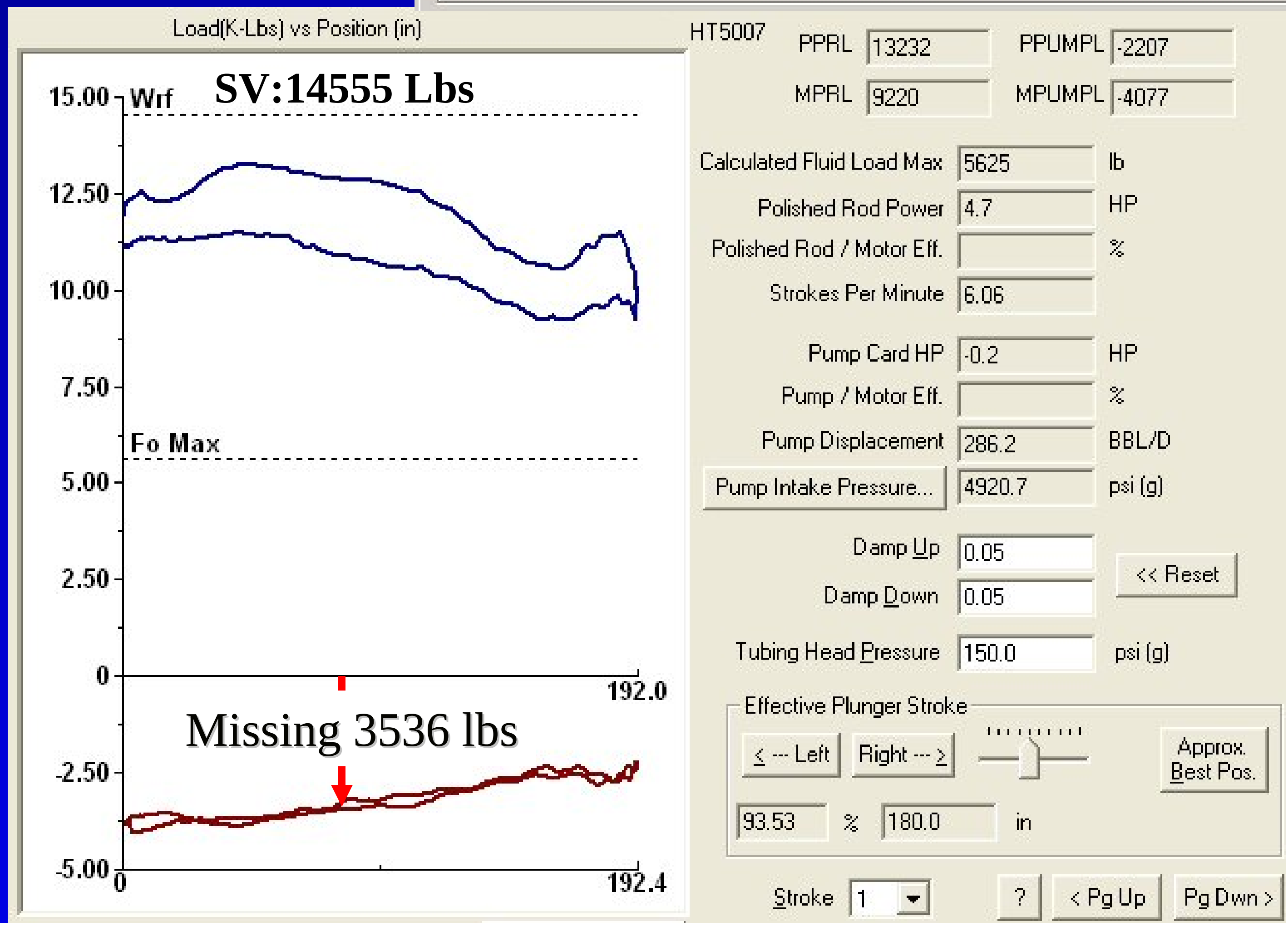
5 Trouble Shooting Flow Charts in Paper

From "Dynamometer Testing for Analyzing the Pumping Well Problem", By C. J. MERRYMAN & D. K. LAWRENCE, SWPSC 1958

Missing 37 3/4" Rods Parted 5365'



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



Missing: Wrf 3536 lbs

INDICATORS OF MALFUNCTION OR TROUBLE

Several valuable indicators can be used in diagnosing well pumping trouble. These are:

(1) Accurate, complete and representative well tests.

(2) Past history of well and equipment performance.

(3) A "healthy" dynamometer card taken when the well producing equipment and down-hole pumping conditions are representative of the normal producing characteristics of the well.

(4) "Before" and "after" dynamometer cards and fluid level charts to pinpoint causes of trouble.

(5) A dynamometer card taken at the time trouble is being experienced which may show:

(a) Overtravel or undertravel.

(b) SV and/or TV measured values which do not correspond to the appropriate calculated values, especially when both valve tests measure the same.

(c) Card area.

(d) Fluid or gas pounds.

(e) Abnormal peak or minimum loads.

(f) Measured counterbalance effect with respect to actual dynamometer card trace.

(g) Actual order of card which can be used to compare with expected order.

(h) Sharp changes in loads, such as sticking plunger, well bumping bottom.

(1) Well Conditions

(a) Has amount of fluid production materially changed?

(b) What is the current prod… compared to that normally … enced?

(c) Is the well producing top all… (in prorated areas)?

(d) Has the GOR increased, o… high?

(2) Annulus Fluid Level Conditions

(a) Is there sufficient submerge…

(b…

(c…

(d…

(3) Surface and Subsurface … uation

(a) Is the pump size o… volume of fluid pr…

(b) Has the sucker r… optimized?

(c) Is there a section … above the pump?

(d) Is the sucker rod … ble with the pump…

(e) Have the stroke le… ber of strokes pe… optimized?

(f) Is the pump setting depth satisfactory?

(g) Does the well have a gas anchor? If so, has the design been optimized?

(h) Is the over-all pump efficiency satisfactory?

(4) Dynamometer Card Characteristics

(a) Is the card shape and appearance the one normally obtained on this well.

(b) Are there indications of overtravel or undertravel?

(c) Does the general card configuration correspond to the harmonic card order expected under the prescribed operating conditions?

(d) Does the card have area?

(e) Do the TV and SV measurements correspond to the calculated values?

(f) Are the PPRL and MPRL normal?

(g) Is the over-all card at the proper location on the building-block load diagram?

(h) Is there a fluid or gas pound present?

(i) Is there an indication of sufficient submergence?

(j) Are there any load anomalies or sudden load changes on the card?

From "Beam Pumping Fundamentals",

By F. W. Gipson and H. W. Swaim, SWPSC 1969

5 Trouble Shooting Flow Charts in Paper

INDICATORS OF MALFUNCTION OR TROUBLE

Several valuable indicators can be used in diagnosing well pumping trouble. These are:

(1) Accurate, complete and representative well tests.

(2) Past history of well and equipment performance.

(3) A "healthy" dynamometer card taken when the well producing equipment and down-hole pumping conditions are representative of the normal producing characteristics of the well.

(4) "Before" and "after" dynamometer cards and fluid level charts to pinpoint causes of trouble.

(5) A dynamometer card taken at the time trouble is being experienced which may show:

(a) Overtravel or undertravel.

(b) SV and/or TV measured values which do not correspond to the appropriate calculated values, especially when both valve tests measure the same.

(c) Card area.

(d) Fluid or gas pounds.

(e) Abnormal peak or minimum loads.

(f) Measured counterbalance effect with respect to actual dynamometer card trace.

(g) Actual order of card which can be used to compare with expected order.

(h) · Sharp changes in loads, such as sticking plunger, well bumping bottom.

(1) Well Conditions

(a) Has amount of fluid production materially changed?

(b) What is the current prod compared to that normally enced?

(c) Is the well producing top all (in prorated areas)?

(d) Has the GOR increased, o high?

(2) Annulus Fluid Level Conditions

(a) Is there sufficient submerge

(b

(c

(d

(3) Surface and Subsurface uation

(a) Is the pump size o volume of fluid pr

(b) Has the sucker r optimized?

(c) Is there a section above the pump?

(d) Is the sucker rod ble with the pump

(e) Have the stroke le ber of strokes per optimized?

(f) Is the pump setting depth satisfactory?

(g) Does the well have a gas anchor? If so, has the design been optimized?

(h) Is the over-all pump efficiency satisfactory?

(4) Dynamometer Card Characteristics

(a) Is the card shape and appearance the one normally obtained on this well.

(b) Are there indications of overtravel or undertravel?

(c) Does the general card configuration correspond to the harmonic card order expected under the prescribed operating conditions?

(d) Does the card have area?

(e) Do the TV and SV measurements correspond to the calculated values?

(f) Are the PPRL and MPRL normal?

(g) Is the over-all card at the proper location on the building-block load diagram?

(h) Is there a fluid or gas pound present?

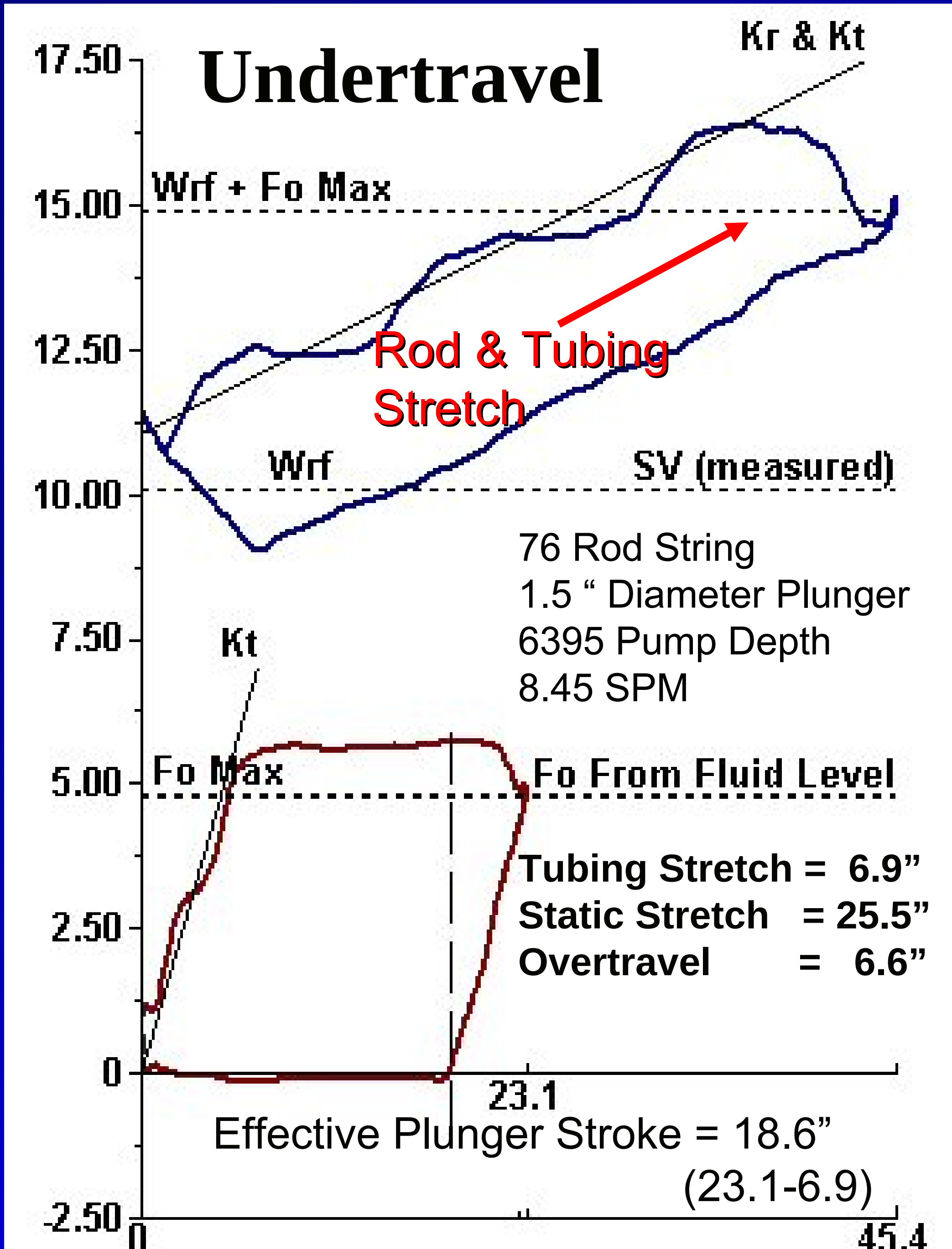
(i) Is there an indication of sufficient submergence?

(j) Are there any load anomalies or sudden load changes on the card?

Two Check List on Next Slide

From "Beam Pumping Fundamentals",

By F. W. Gipson and H. W. Swaim, SWPSC 1969



Plunger too Large for Rods

Severe under travel occurs

when the sub surface pump diameter is too large for the sucker rod string.

Checklist A. Normal cards or overtravel cards with SV and TV measuring the same.

POSSIBLE SITUATIONS	Possible Cause Yes	Possible Cause No
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		
17.		
18.		
19.		
20.		

Checklist B. For use in analyzing undertravel situations or conditions.

POSSIBLE SITUATIONS	Possible Cause Yes	Possible Cause No
1. Sand problem		
2. Paraffin problem		
3. Scale problem		
4. Too many rods		
5. Rods underdesigned		
6. Pump overdesigned		
7. Too much tubing		
8. Crooked tubing		
9. Crooked hole		
10. Other types of down-hole friction		
11. Low API gravity fluid		
12. Stuck pump		
13. Improper lubrication of down-hole pump		
14. Stuffing box too tight		
15. Tubing not anchored		
16. Rod guides, paraffin scrapers		

Analyze Failures to Prevent Failures

1. Increase system run times or Mean Time Between Failures [MTBF] ~ reduce failure frequency.
2. Tear down analysis of downhole equipment failure.
3. Inspect failing component and identify cause of failure.
4. Store results of analysis in a database.
5. Analyze past failure data to prevent future failures.
6. Personnel can become more effective in making recommendations on equipment and equipment configurations; if reasons for failures known.

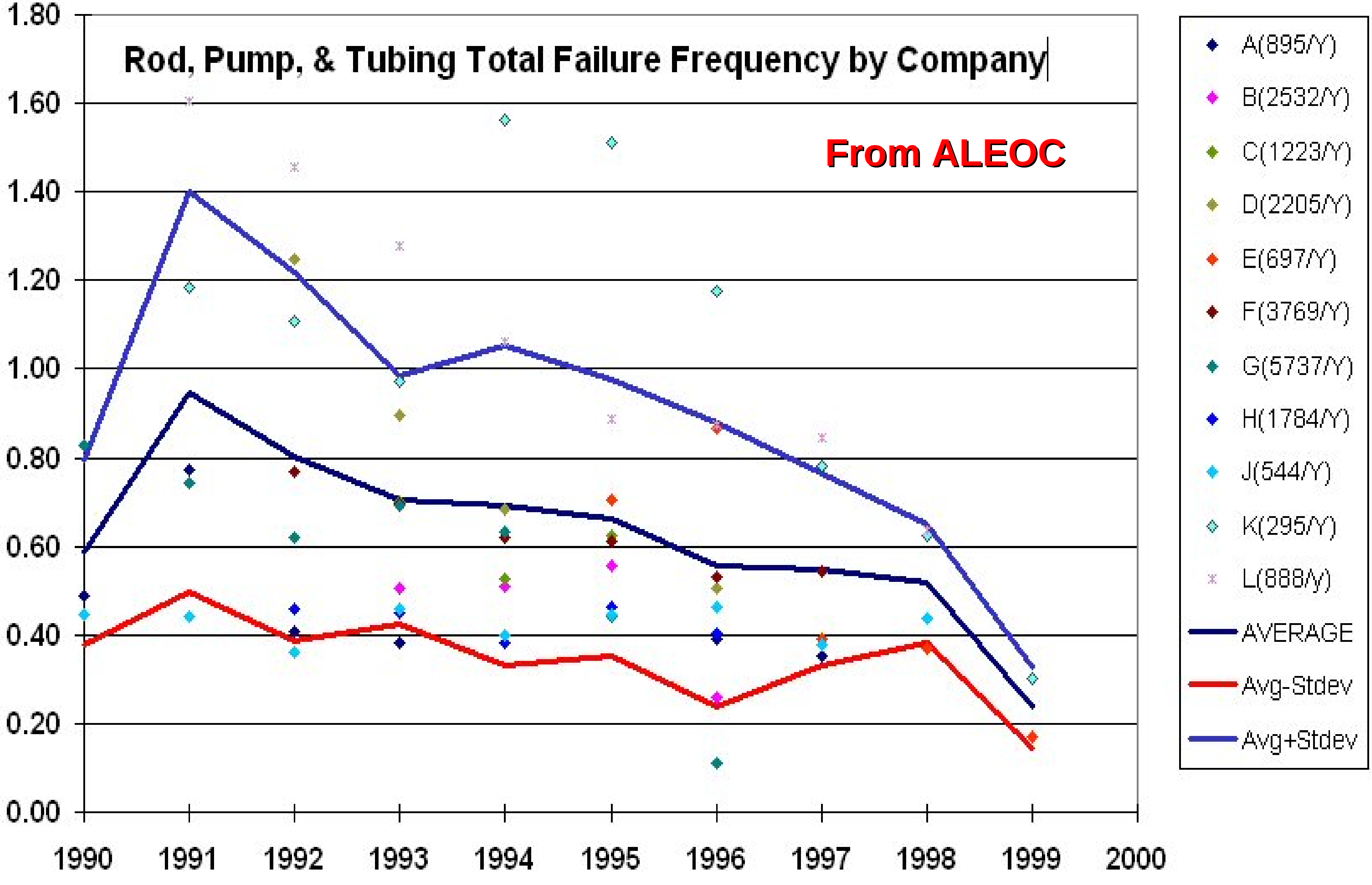
Practices Which Result in Increased Equipment Life

1. Correct design defect through diagnosis of the reason a failure occurred.
2. Reducing equipment misuse by operating equipment within operational limits.
3. Preventing equipment with defects from being installed in a well.
4. Prevent mishandling of equipment.
5. Using reasonable service factors.
6. Frequent monitoring of the equipment's performance.

Expected Gain from Setting Goal of Reducing Failures

1. A reduction in operating cost.
2. Sudden drop in cost not expected, because most changes in operating practices increase equipment life.
3. Operational changes that prevent failures from occurring will have an immediate impact on improving the MTBF.
4. Preventing failures can be accomplished by monitoring the operation of artificial lift equipment, identifying a problem and making a change before the equipment fails.

Expect a 0.4 Failure Frequency.



What does the ALEOC Failure Data Show?

1. Making an effort to analyze the well's operation and ***taking action*** to fix problems discovered is the ***MOST important requirement***
2. Everyone in the study group ***recognized their performance could be improved*** and they took action to reduce failures
3. Their ***different actions*** with-in their individual companies ***resulted in a reduction of failures*** for all companies in the study group
4. ***Expect a 0.4 Failure Frequency in Your Field***

Problem Well Definition?

1. More that 2 failures per “year”.
   – What is a Failure?
2. Same type of failure - two in a row.
3. No Fluid in the Tank.
4. There is noticeable Leak w/ fluid on the Ground.
5. Well’s Production has decreased.
6. Pumping Unit is not Running.
7. Fluid Level is not at the Pump.
8. System Efficiency is less than 35%, Surface Efficiency is too low?

Suggested Number 1 Problem

Maintaining high pump volumetric efficiency

How to fix:

- **Eliminate Gas interference.**
- **Match pumping capacity to wellbore inflow.**
- **Pump a Full Stroke of liquid by controlling run time with a POC or Timer**

What is your worst Problem?

1. 50% of participants said handling gas was their #1 problem
2. Rod on Tubing Wear w/ Spray Metal Couplings (Have tried both)
3. Sand and/or Foreign Material in Pump
4. Corrosion

People Problems?

1. People resist change brought on by new technology. Not willing to change. Not same goals. Need Education. Need Communication.
2. To Busy.
3. Upper management support. Don't have it and project/best practice fails.
4. Justify expenses based on best practices and do not try to save money on line item expenses.
5. People need training, everyone is over 45 years or age, no new blood, everyone is going to retire.
6. 7 year cycle – Everyone that knows moves on, after 7 years must re-learn solution to problem…

Identify Problems?

1. Trend & track data to identify ***if*** a change in operating practice results in increased problems.
2. Use field wide system for monitoring & to ID problem.
3. Need failure meeting every month & frequent well review.
4. Record every failure, look at failed component, decide to do something, set goals, have good relationship with pump shop – it should be OK if they tells you are doing something "stupid".
5. Use integrated solution team, ID root cause, use best practice team, inspect failures, team needs rod/ pump/ chemical/ work-over/ company man.

Keys to Success of Using Technology

1. Local management support required
2. Someone must be responsible to use information.
3. Training required for all potential users
4. Must commit to up-front work to input data for wells.
5. Correct field information must be obtained in timely manner.
6. Input changes in equipment into System (Sucker Rod, S, N, Pumping Unit, etc...)

Keys to Success (Continued)

7. Local control/update to system critical.
8. Must use system on a daily basis as part of job
9. Expect to discover something new about your wells that you did not know.
10. Consistent review of data will decrease operating cost.
11. Lower Cost & Increased Production pays out technology

Questions ?