Ask Echometer Online Seminar – July 15, 2020

Dynamometer Workshop

TOTAL ASSET MONITOR (TAM)

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

"Efficient and Accurate Monitoring of Rod Pump Well Performance Using Real Time Data Processing and Visualization", McCoy, Becker, Capps, Podio, Rowlan , OKC POS 03/23/2013 SPE 164485

"A Polished Rod Transducer for Quick and Easy Dynagraphs", McCoy, Jennings, Podio SWPSC 1998

"Advances in Dynamometer Technology", Rowlan, McCoy, Podio SWPSC 2004

Carrie Anne Taylor	**E-mail:** Carrieanne@Echometer.com
Gustavo Fernandez	Gustavo@Echometer.com
O. Lynn Rowlan	Lynn@Echometer.com
A. L. Podio	Tony@echometer.com

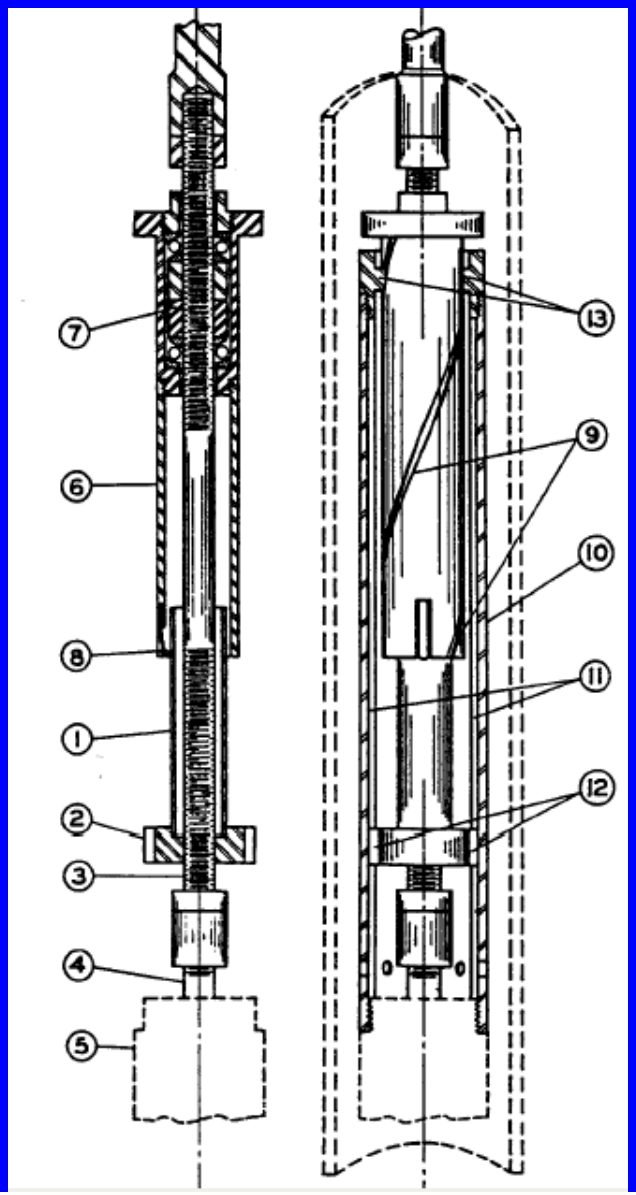
Acquiring Dynamometer Cards

- Recording load and position data on sucker rod lifted wells with a dynamometer transducer has been performed in the oil field for many years.

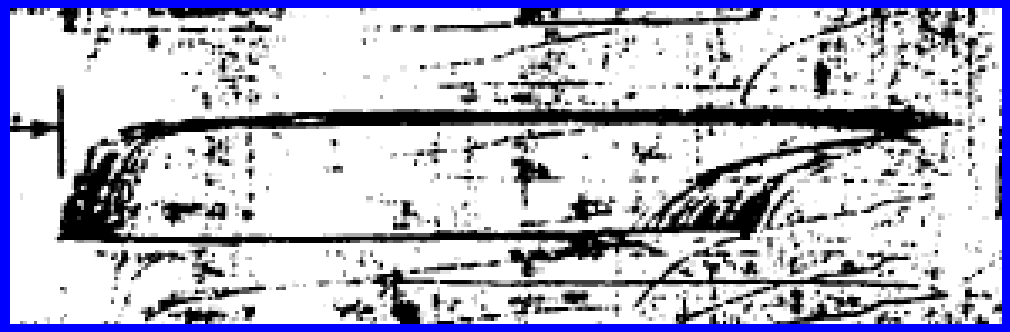
- Early Dynamometer Examples:
  - 1950's the popular Johnson-Fagg dynamometer .
  - Leutert dynamometer .

- Current portable dynamometer technology :
  - High performance digital data acquisition systems
  - Quick, accurate data, safe and easy to use .

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



1. Developed Bottomhole Instrument to Record Action of Pump
2. Field Tested Pump-dynagraph Measurement
3. Interpretation of Pumping Action from Dynagraph Cards

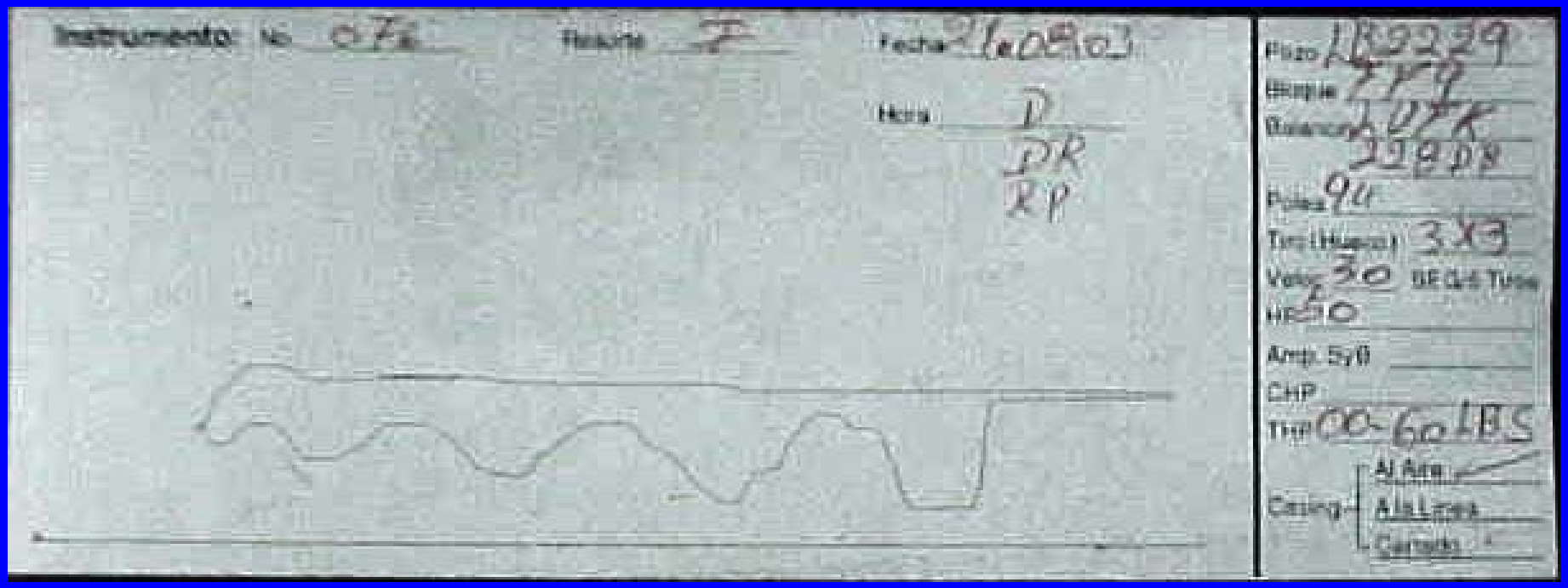


Popular 1950's Portable Dynamometer

1. Integral Hydraulic pump extends two pistons supporting the load using hydraulic pressure
2. Calibrated springs in the registration unit convert the hydraulic pressure into load
3. String attached to the wellhead turns the registration unit in proportion to the polished rod position

Inaccurate load measurement of up to 40% is a documented problem when using the Leutert

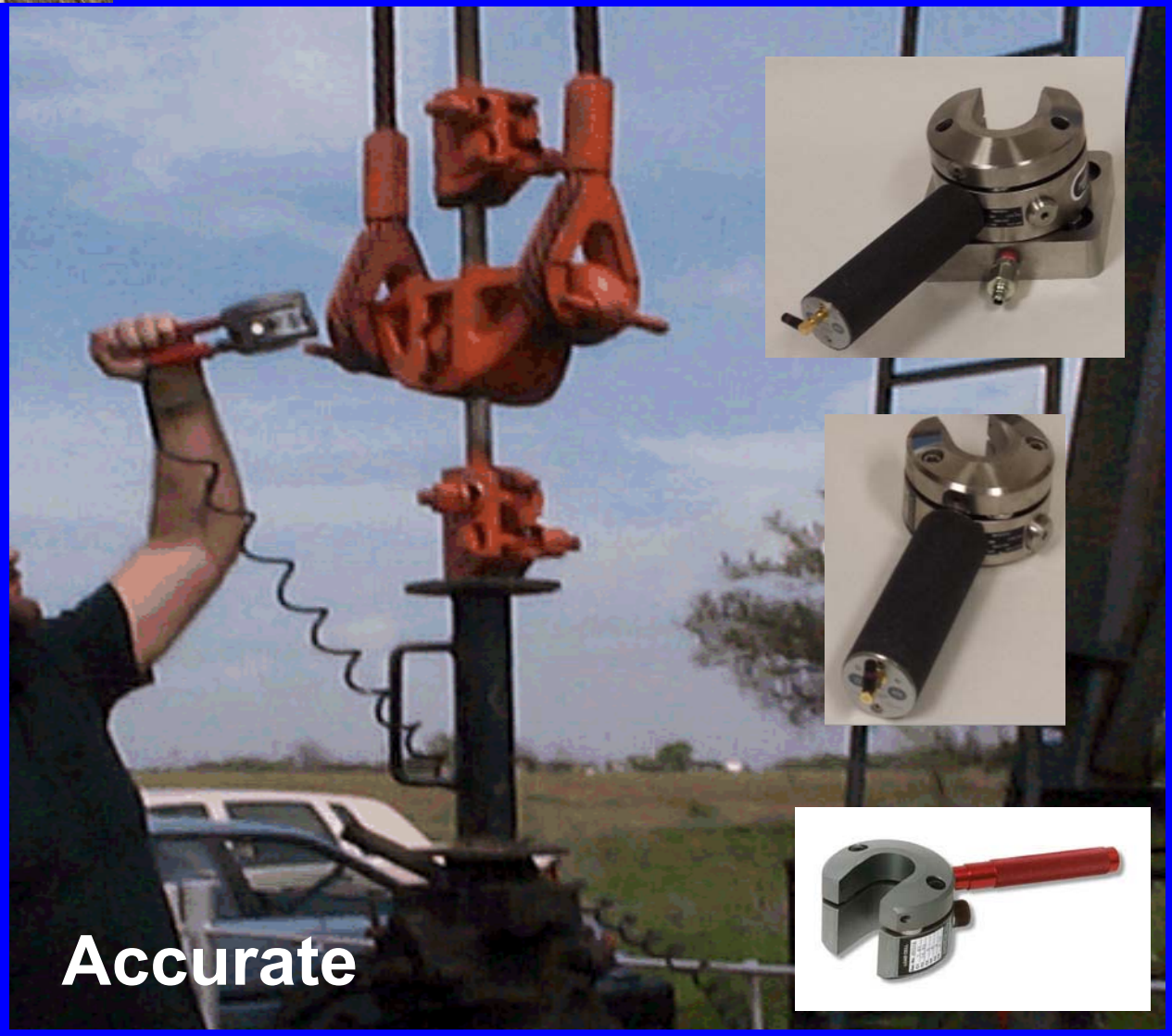
Example Leutert Dynamometer Card



1. Scribed load and position onto the wax dynamometer card for each stroke
2. Disadvantage of wax dynamometer card systems is that the load and position traces have to be tediously digitized by hand, before any detailed analysis can be performed

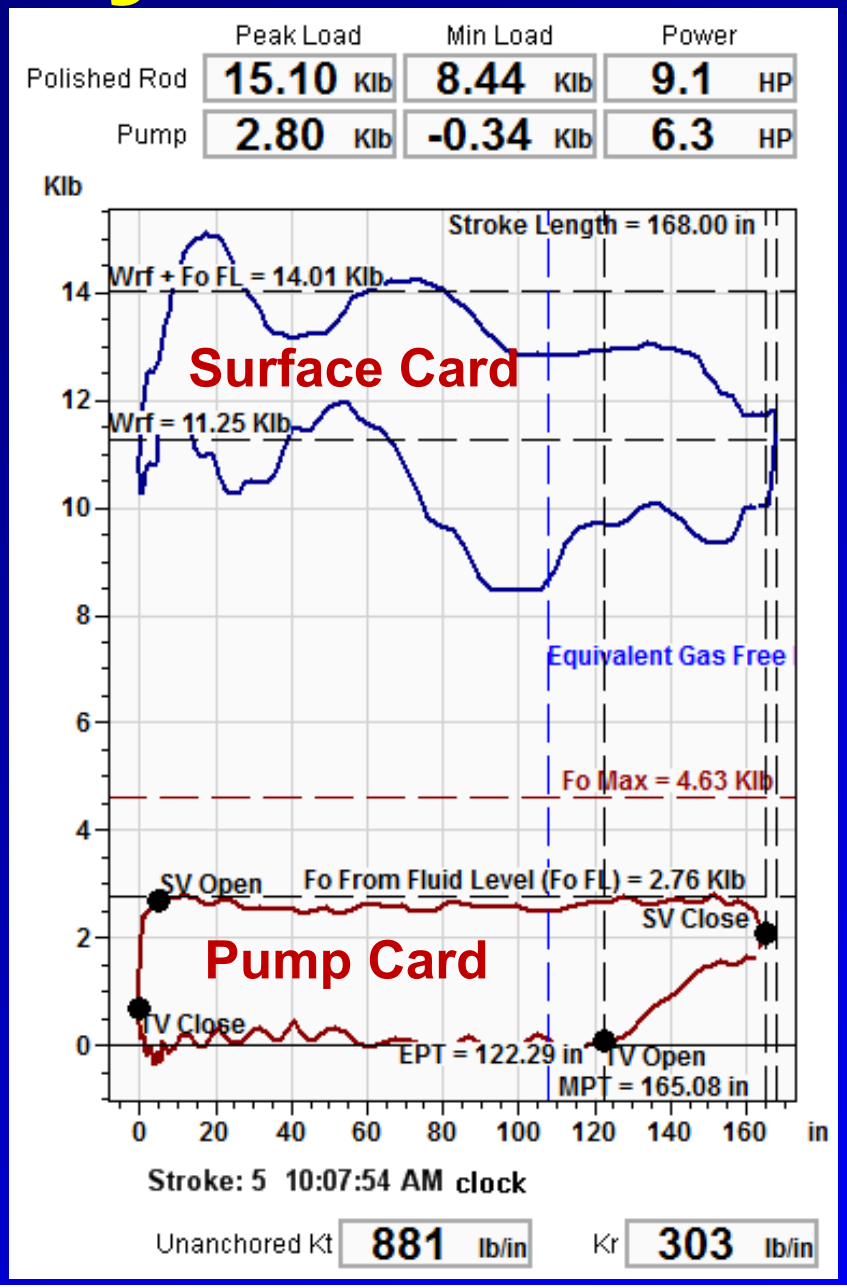
Use Any of these Transducers to Perform a Dynamometer Survey

Safe & Quick



Accurate

Dynamometer Card Definition

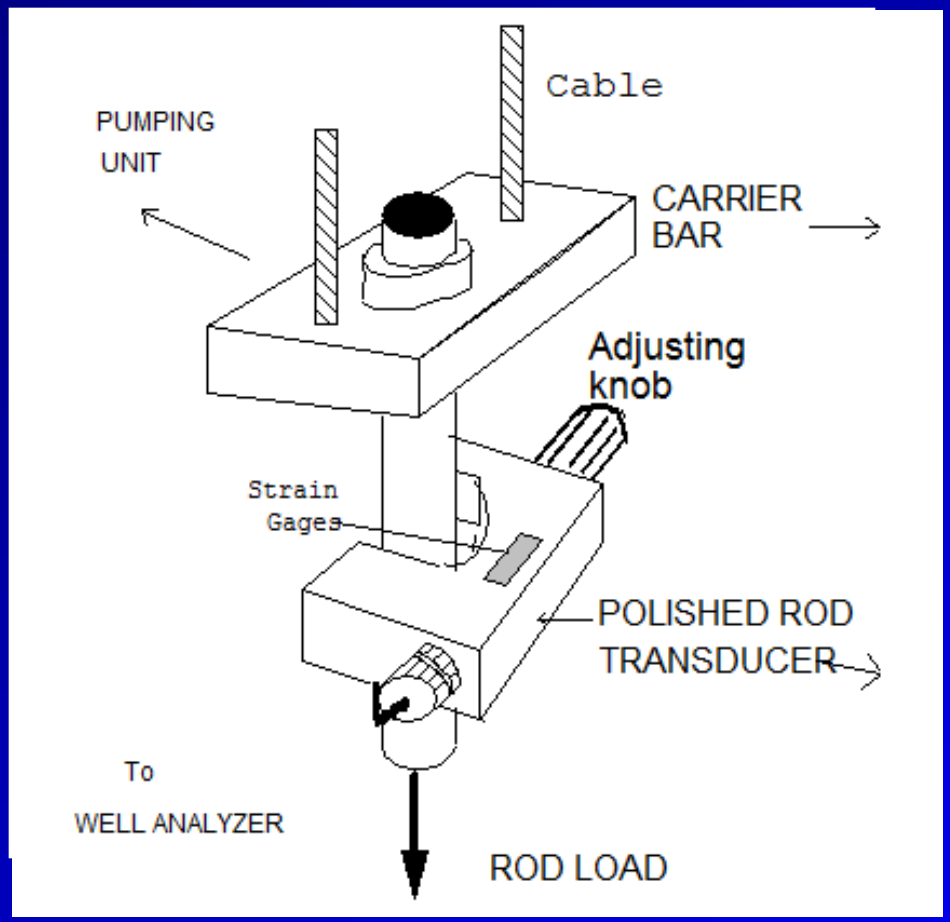


1) <u>Surface dynamometer card</u> is the plot of the measured rod loads at the various positions throughout a complete stroke; the load is usually displayed in pounds of force and the position is usually displayed in inches.

2) <u>Pump dynamometer card</u> is a plot of the calculated loads at various positions of pump stroke and <u>represents the fluid load the pump applies to the bottom of the rod string</u>.

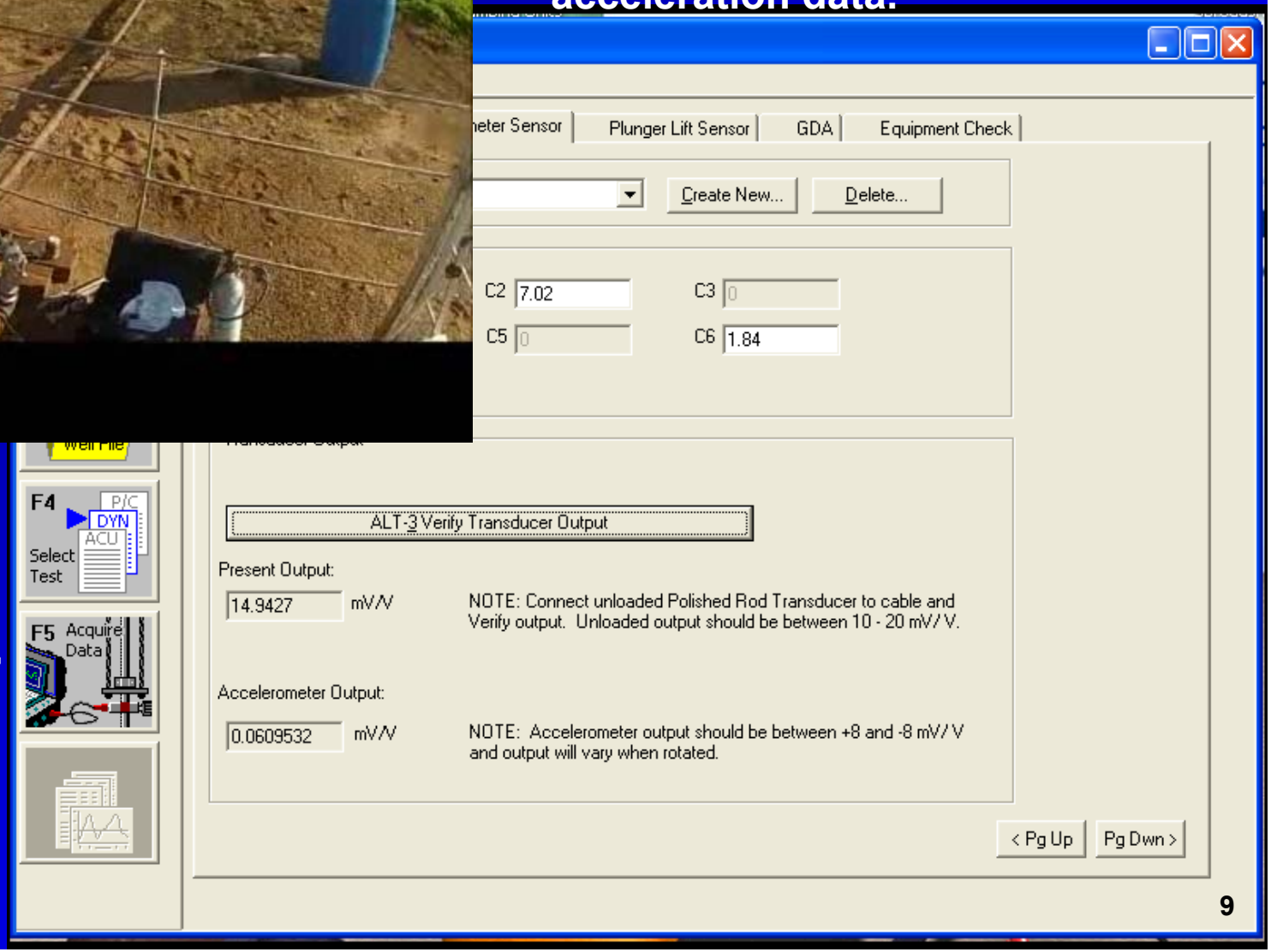
POLISHED ROD TRANSDUCER

INCLUDES ACCELEROMETER FOR POSITION



Fast, Convenient, Reasonably Accurate, Load and Position Data

1. PRT attaches to the polished rod.
2. Load - PRT output is proportional to the change in polished rod diameter due to the change in PR loading.
3. Position – by processing PR acceleration data.



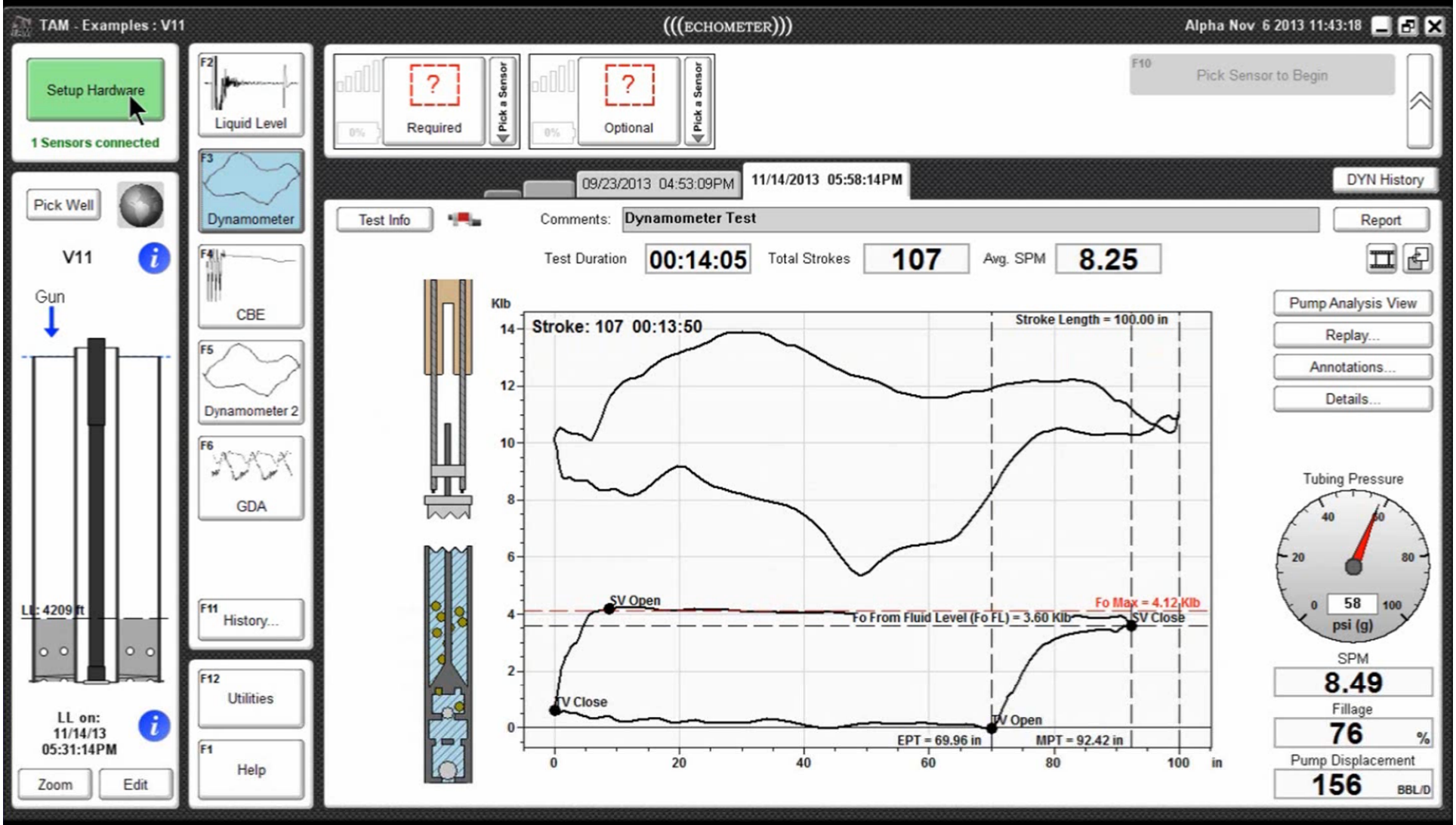
TWM

w/ wired PRT

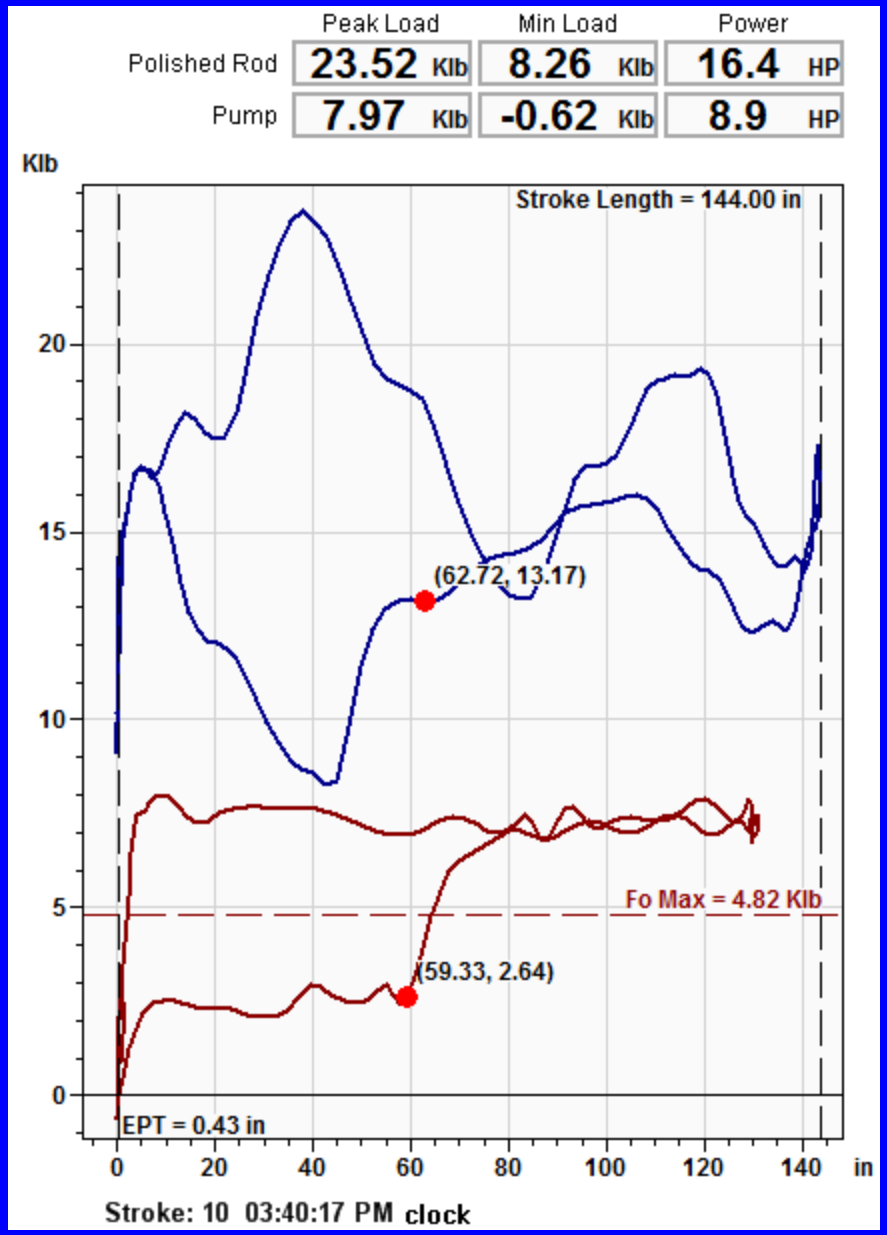
TAM

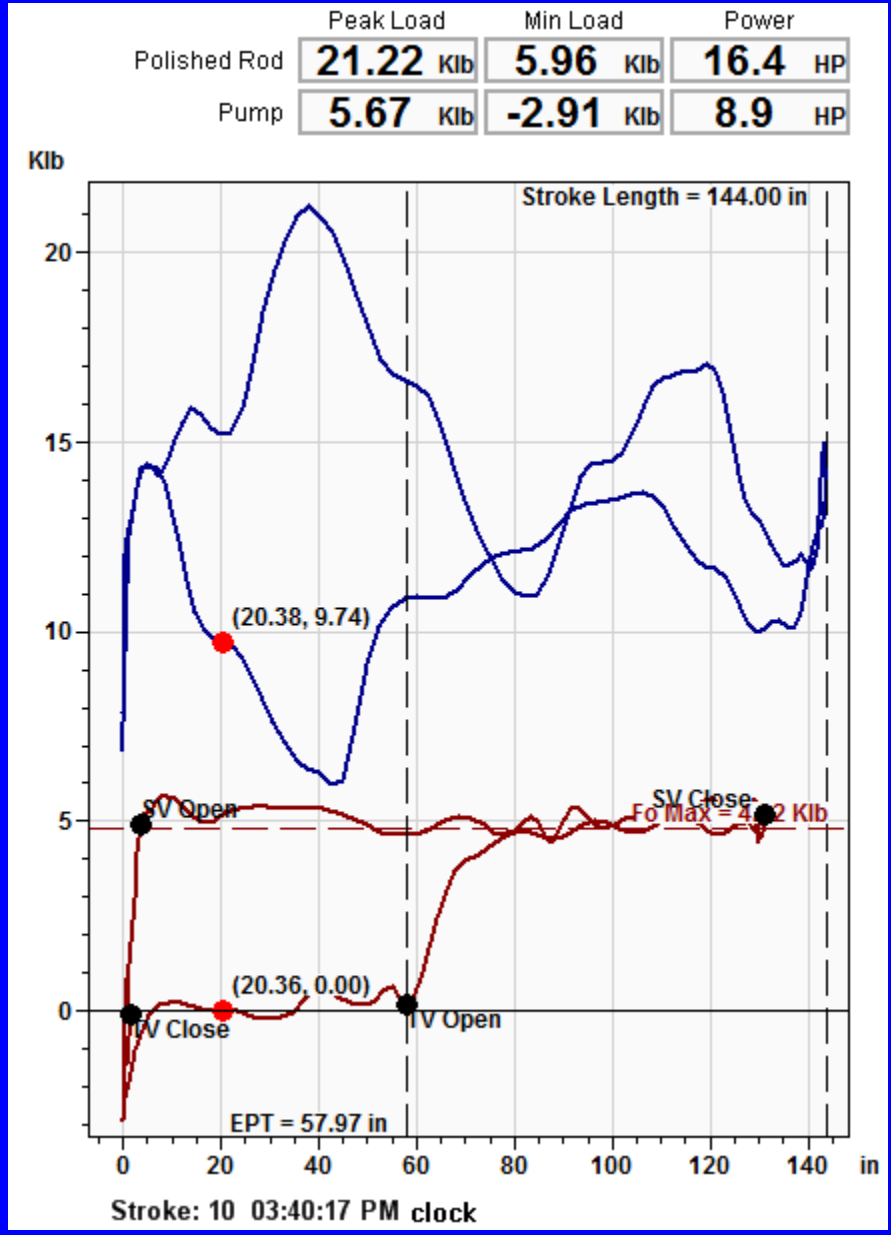
Attach
Wireless PRT
and Initiate
Data
Acquisition
vs
Use TAM
Software to
Start Test

Use TAM to Guide WPRT Installation



Min. Pump Card Load Sets PRT Zero Offset





Load Shifted by Tag **CORRECTED**

Dynamometer Load Using the PRT

1. TAM acquires the diameter change of the polished rod with the PRT
2. Knowing Polished Rod area with change in diameter, Poisson's ration, Modulus of Elasticity calculates change in surface load
3. TAM software calculated the TVD weight of rods in fluid (…which is not measured by the PRT)
4. TAM uses the computed weight of rods in fluid with the wave equation to calculate the change in load at the end of the rod string versus position.
5. Change in loads of surface and downhole dynamometer cards become calibrated loads, when TAM uses the principle that the mechanical load the pump applies to rod string equals *zero*, after the traveling valve opens and is moving on the down stroke
6. TAM determines the Zero Offset equal to the load required to shift the relative pump loads to set the pump card on the zero load line.
7. Zero offset is applied to both the relative surface loads and pump loads to calibrate the PRT measured change in diameter to become equal to calibrated loads.

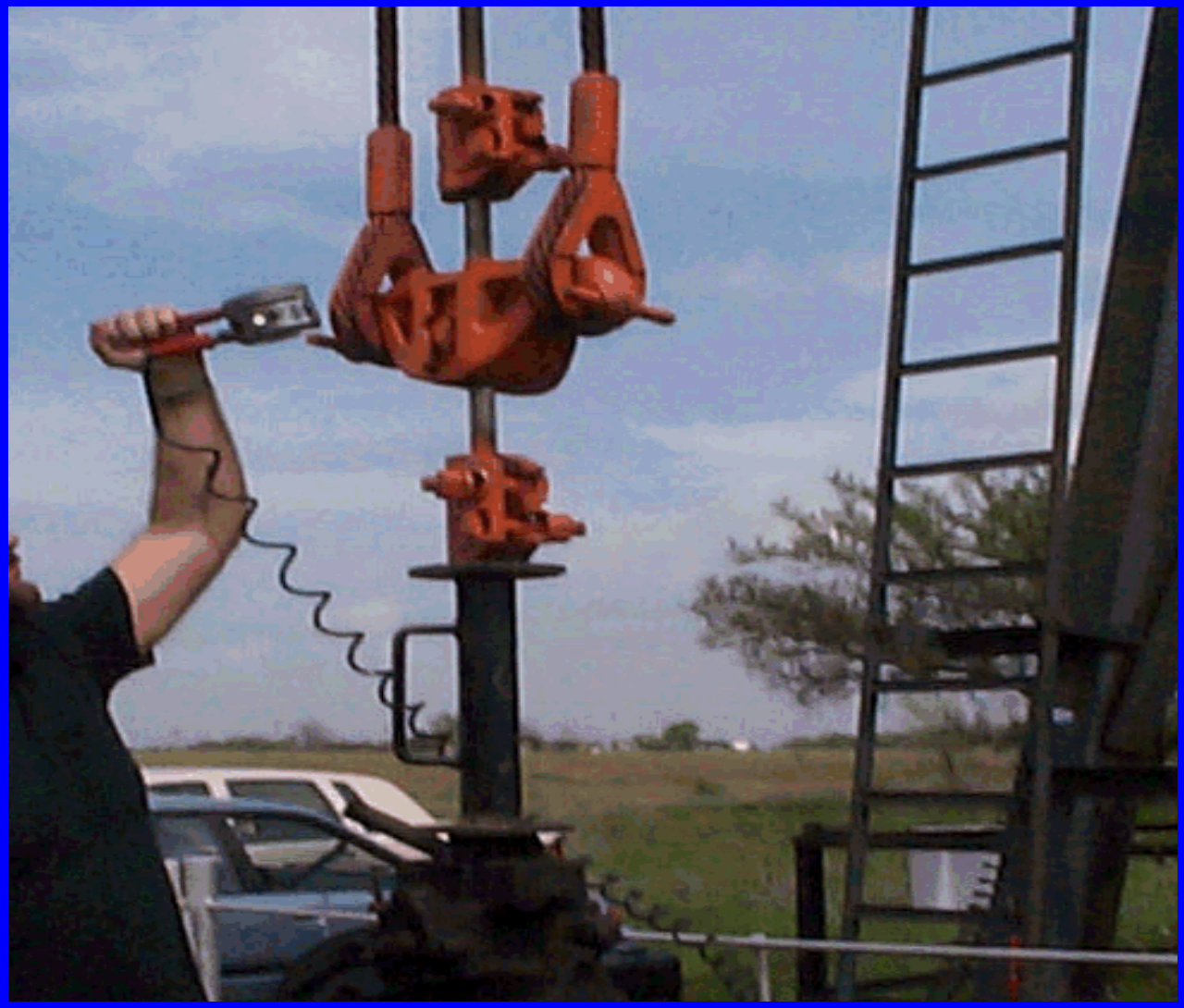
30k HORSESHOE TRANSDUCER

POSITION FROM ACCELEROMETER

1. Highly accurate transducer
2. Provide a precise load value.
3. Load cell placed on polished rod between the permanent polished rod clamp and the carrier bar.
4. Sensor acquires the acceleration of the polished rod.
5. Software calculates velocity and position of the polished rod by integration of the acceleration signal vs. time.

Place 30k HT on Carrier Bar Below Polished Rod Clamp

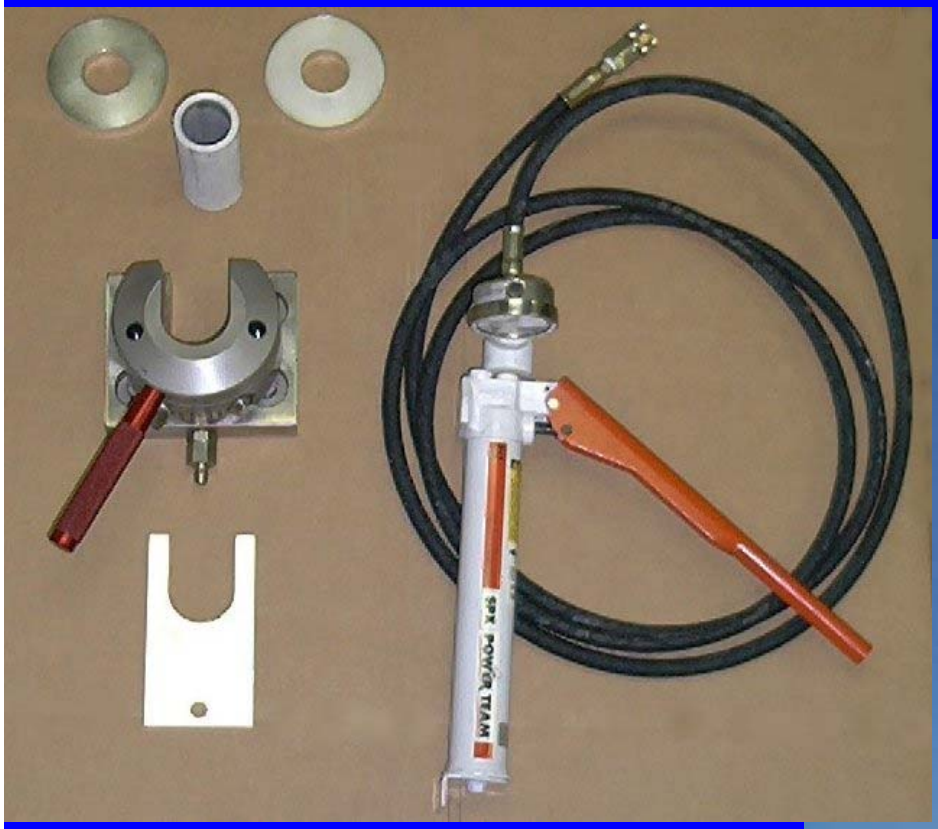
The brake or clamps could slip and for safety reasons **NEVER** place hand between carrier bar and polished rod clamp.



50k HORSESHOE TRANSDUCER

INCLUDES ACCELEROMETER

SAFE, FAST, CONVENIENT, ACCURATE LOAD & POSITION



Spool & Washers Mounted on Well

1. Permanently Install Spool Assembly on the Well.

2. Spool fits over the polished rod between the carrier bar and the permanent polished clamp.

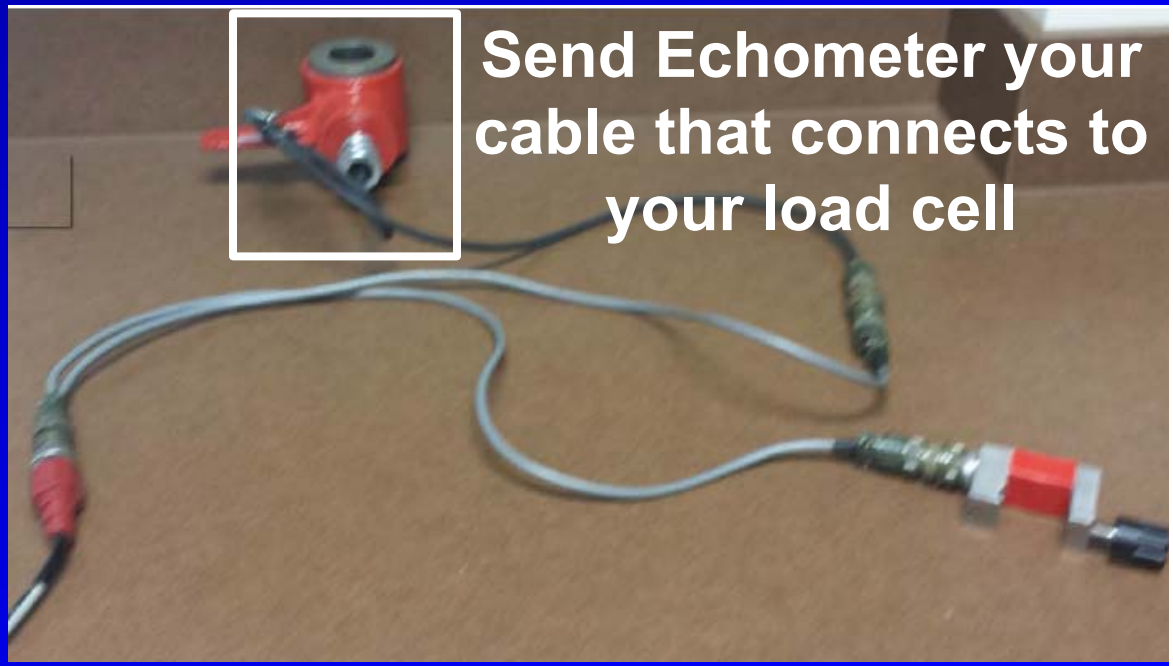
3. Spool assembly consists of upper washer, lower washer and 5" long (2" OD) steel tube; separate the two washers.

50k HORSESHOE TRANSDUCER

Permanently Mounted Donut Load Cell Accuracy Considerations

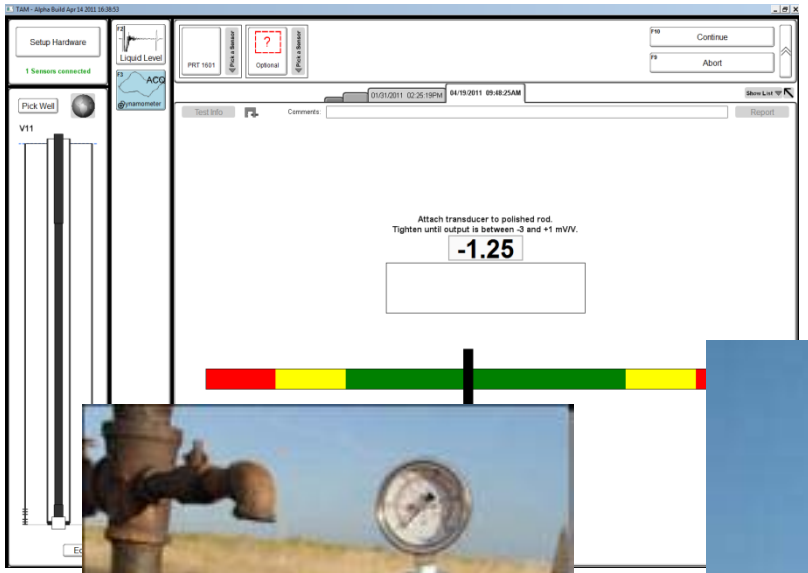
1. Operator has Load Cells mounted on many wells.
2. Damage to the load cell
3. Calibration of the load cell
3. Not centrally loaded at the top or bottom
4. Calibration of the controller.

Accelerometer Special



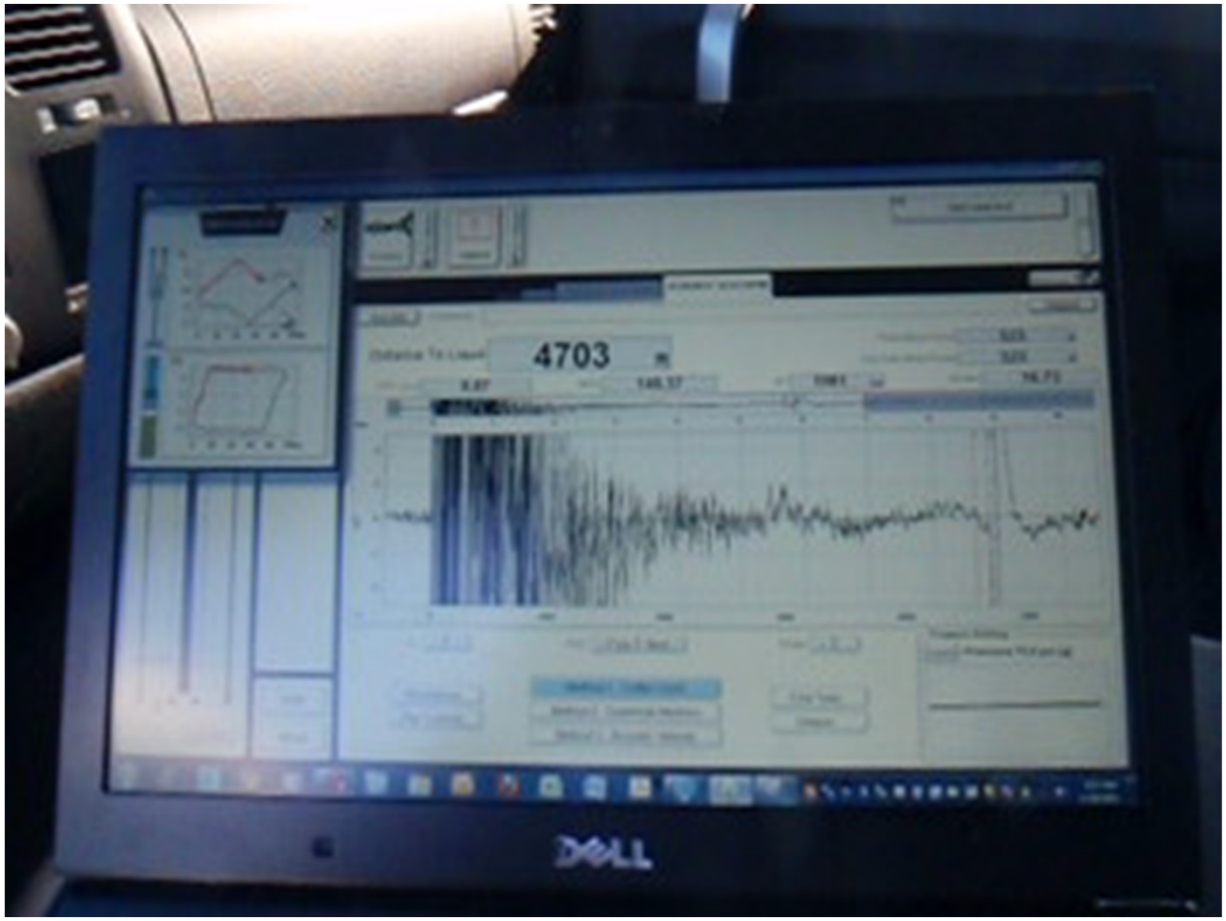
Use Accelerometer in PRT

Sensor Installation and Operation



Installation and start of acquisition is controlled at the sensor via switches and LEDs or at the laptop screen buttons

Simultaneous Fluid Level Acquisition and Real Time Pump Card Display



Continuous acquisition of dynamometer provides reliable pump performance.

Multiple fluid level records acquired simultaneously with dynamometer.

See Detailed "How To" on Web:

https://www.echometer.com/Support/How-Tos

How To PDF – How to acquire data at the well and perform various test using TAM or TWM

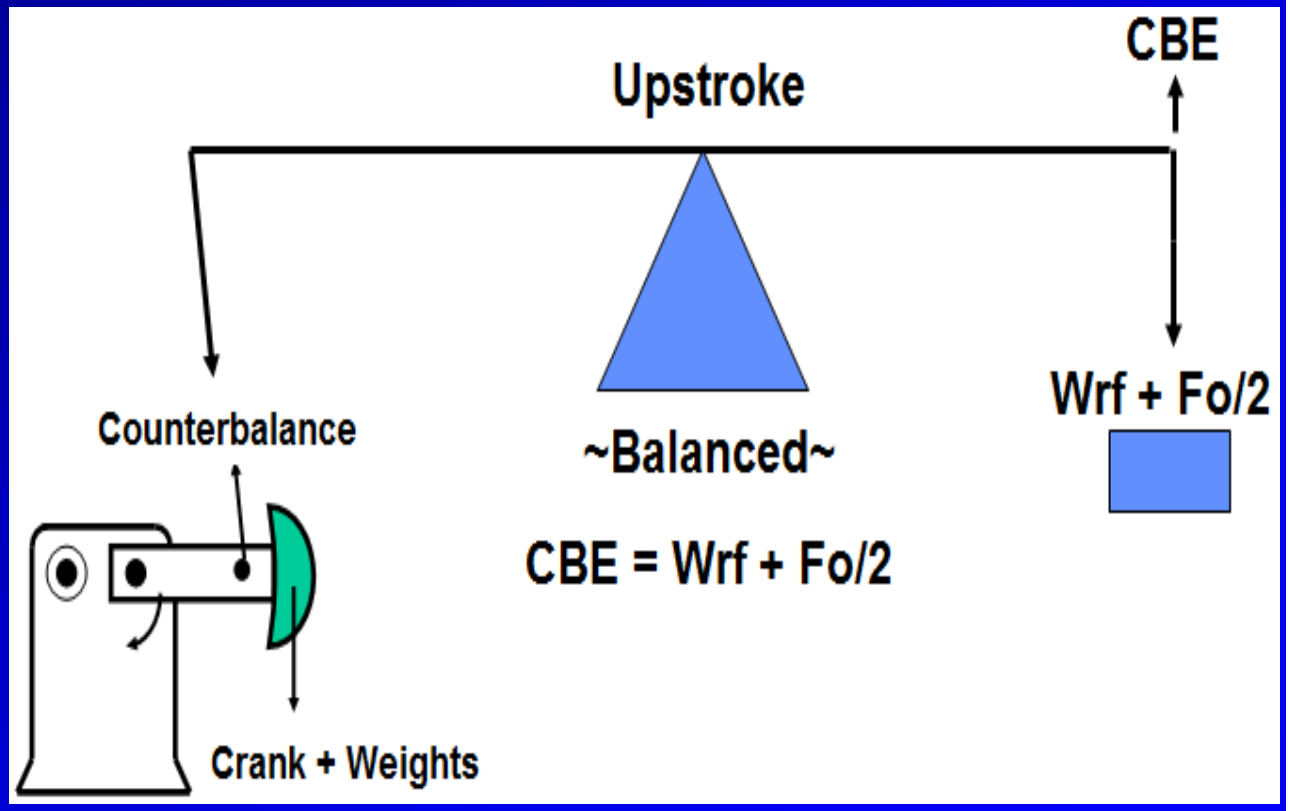
1. HowToPFL.pdf
2. HowToPlungerLift.pdf
3. HowToPower.pdf
4. HowToPRT.pdf
5. HowToValveCheck.pdf
6. HowTo30K.pdf
7. HowTo50K.pdf
8. HowToCBELoad.pdf

1. HowToPFL_Wireless.pdf
2. HowToPlumgerLift_Wireless.pdf
3. HowToPower_Wireless.pdf
4. HowToPRT_Wireless.pdf
5. HowToValveCheck_Wireless.pdf
6. HowTo30K_Wireless.pdf
7. HowTo50K_Wireless.pdf
8. HowToCBELoad_Wireless.pdf

Use Dynamometer Transducer to Determine CBE Load

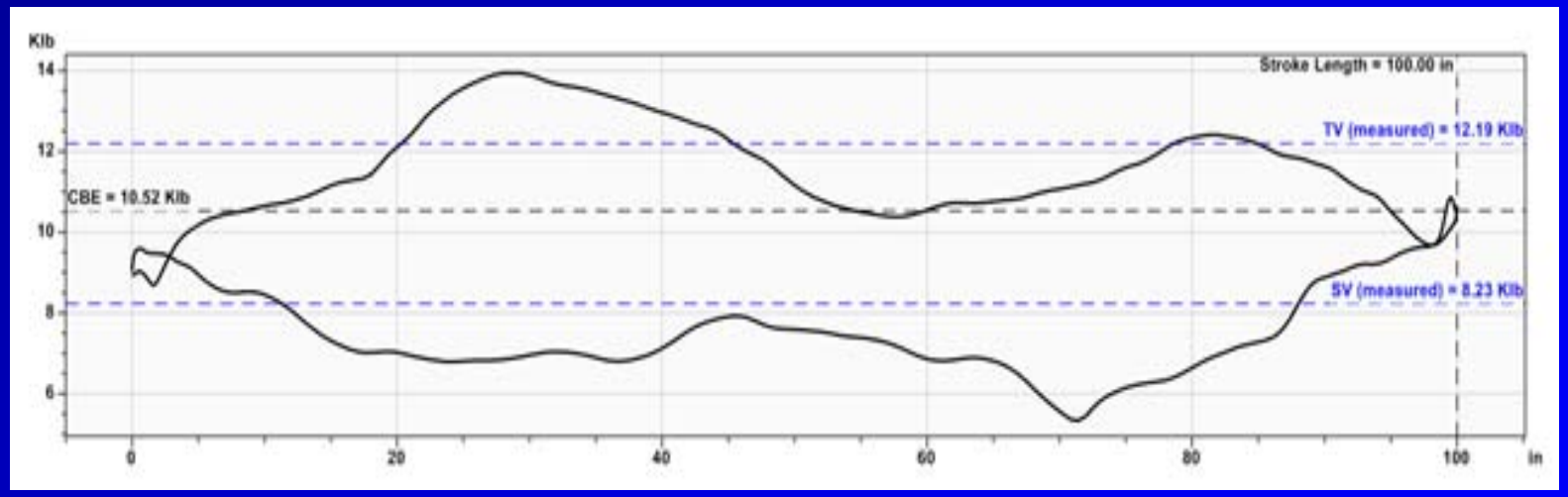
Definition of **Counterbalance Effect Load (CBE):**

Weight at the polished rod that balances the counterweights on the upstroke with crank's level.



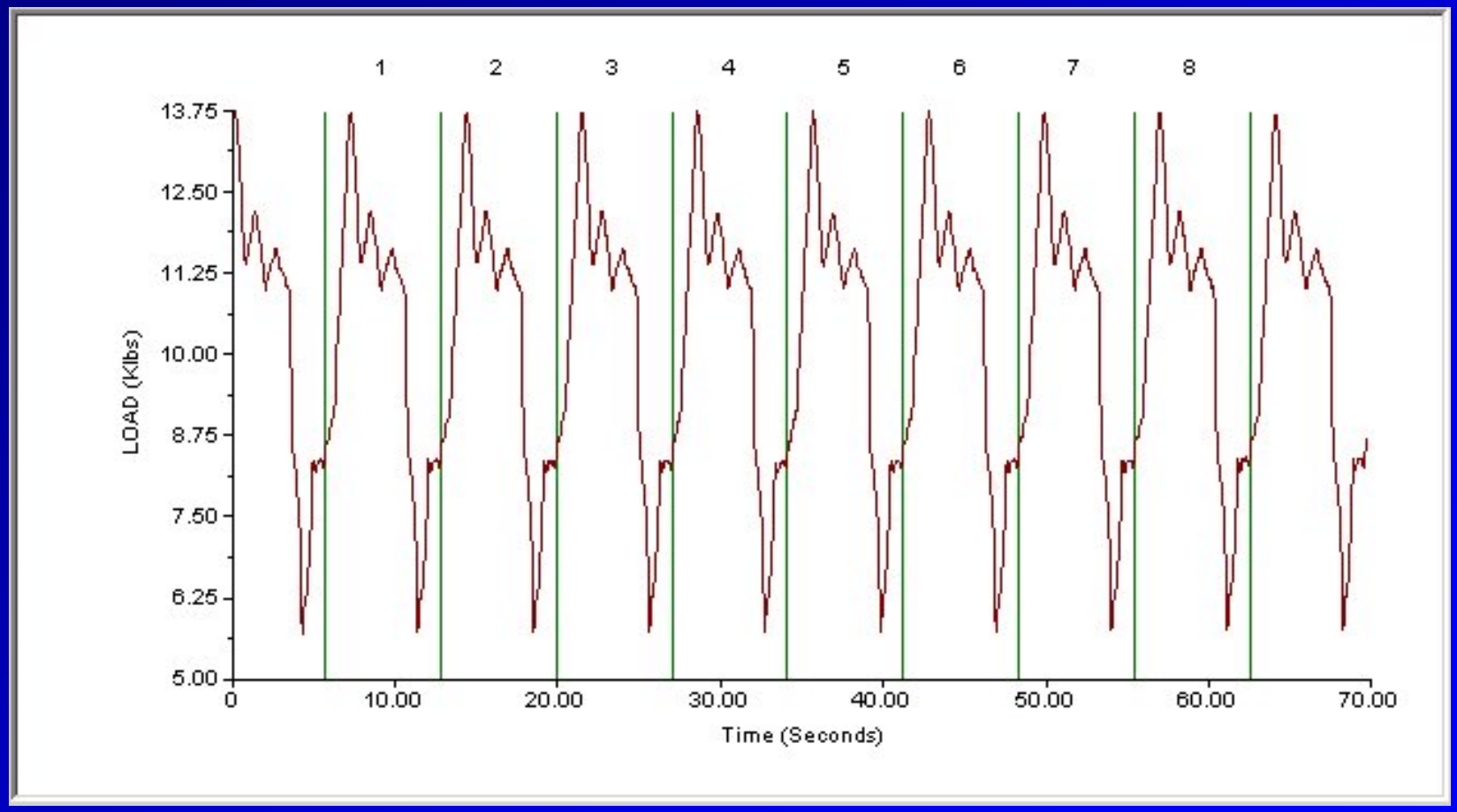
Counterbalance Effect (CBE) Test

1. Requires a properly functioning brake.
2. Counterbalance effect load must be between the traveling valve load and the standing valve load.



3. Will not work when fluid slippage through the pump is rapid and the fluid load quickly transfers from the rods to the tubing.

Polished Rod Loads vs. Time



Acquired surface dynamometer loads are used in determining the mechanical loading of the unit's beam and the unit's gearbox.

Common Sources of Error in the Torque Calculations

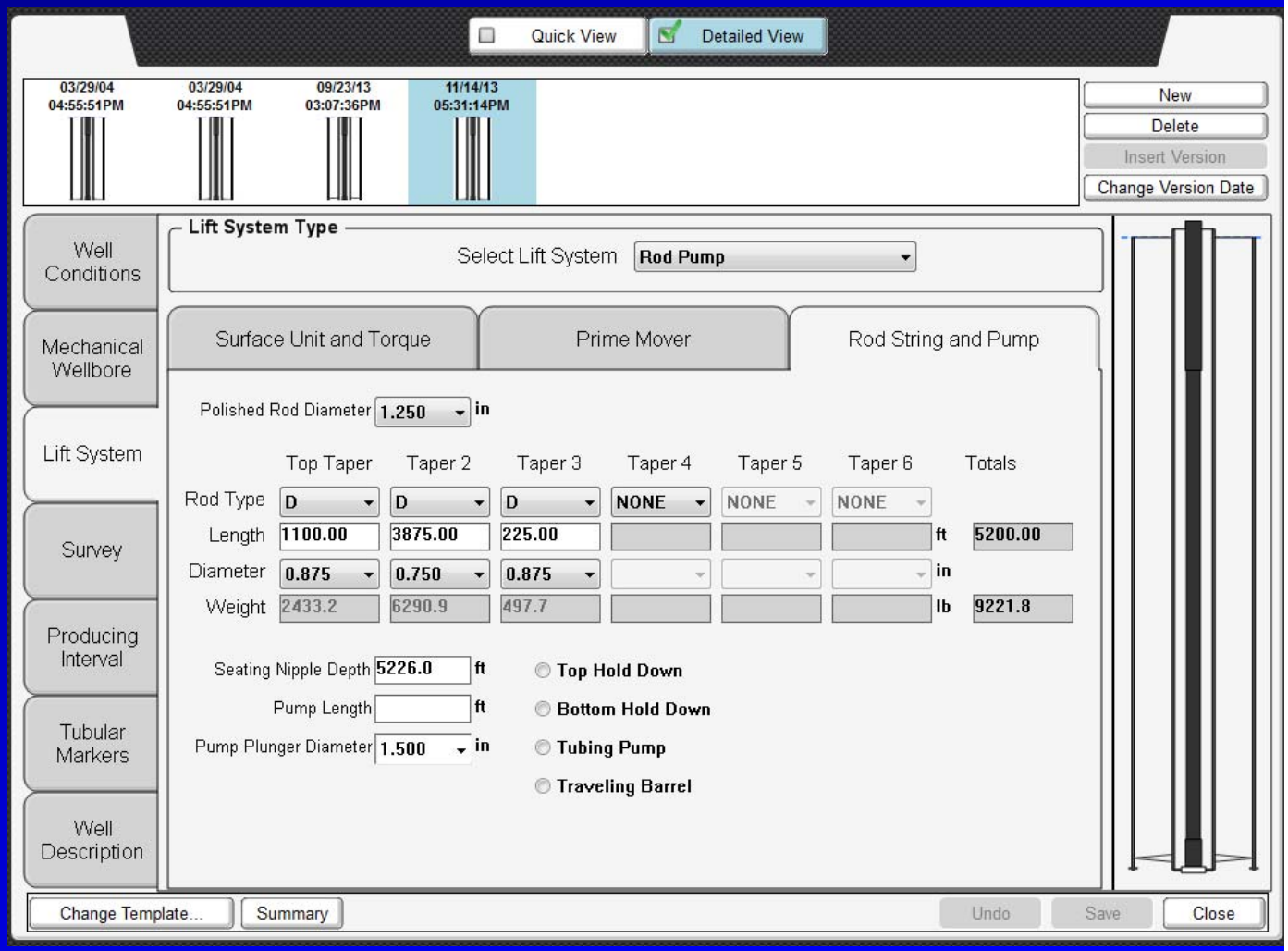
1. Wrong pumping unit is selected.
2. Pumping unit not in the database .
3. Field assembly of the pumping unit results in dimensions not matching database.
4. Wrong radius/stroke length.
5. Incorrect direction of rotation.
6. Wrong CBE or CBM values.

Must use calibrated load cell for CBE test, cannot use PRT because PRT measures change in load.

Always Verify Well Data

1. From **Mechanical Wellbore** Tab and verify the well data is representative.

2. For Dyno surveys be sure to enter Rod Type, Rod Length, Rod Diameter, Pump Plunger Dia., Pump Intake, Polished Rod Diameter, fluid gravities, and production rates.



Surface Unit and Torque Tab Select Torque Method

Surface Unit and Torque | Prime Mover | Rod String and Pump

Surface Unit

Manufacturer: Lufkin Conventional
Class: Conventional
API: C-320D-256-100
Model:
Stroke Length: 100.00 in
Rotation: CW CCW
Change
Automatically Detect Valve Tests

Counterweights Database

Counter Balance Moment (Existing)
500.9 Kin-lb
Counter Weights...
Weight of Counter Weights: 5308.0 lb

For Net Torque Calculations Use

CBM From Counterweights Database
CBM: 500.9 Kin-lb CBE: 10.47 Klb

CBE Manually entered
CBE: 0.00 Klb CBM: -27.8 Kin-lb

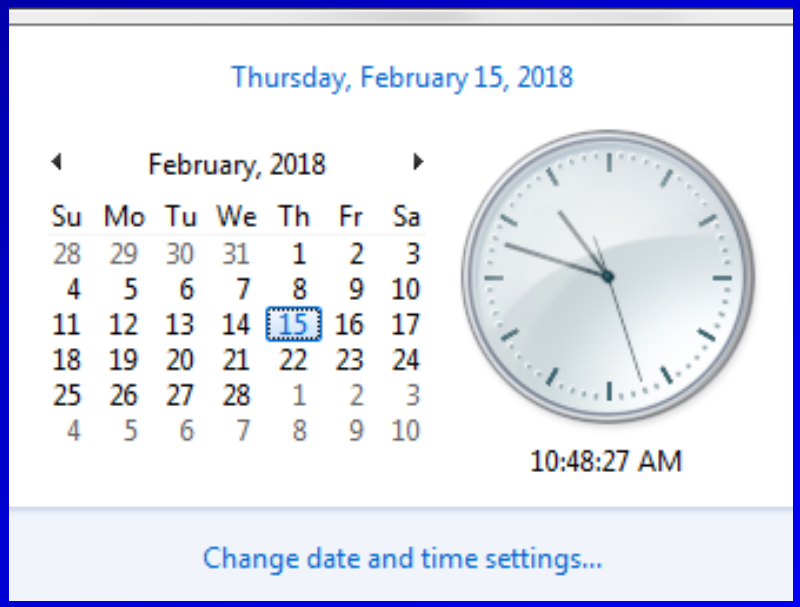
Use	Date/Time	CBE	CBM
	03/29/2004 04:38:48PM	11.20	537.8
	09/23/2013 04:07:10PM	11.26	540.6
	11/26/2013 04:47:13PM	10.75	514.8

1. An accurate description of the pumping unit's API geometry is required for a correct analysis.
2. The API dimensions for a pumping unit are either hand entered or selected from the pumping unit library database.
3. It is VERY IMPORTANT that the correct unit API description be selected in the well file.

CBE Test Setup and Acquisition Procedures

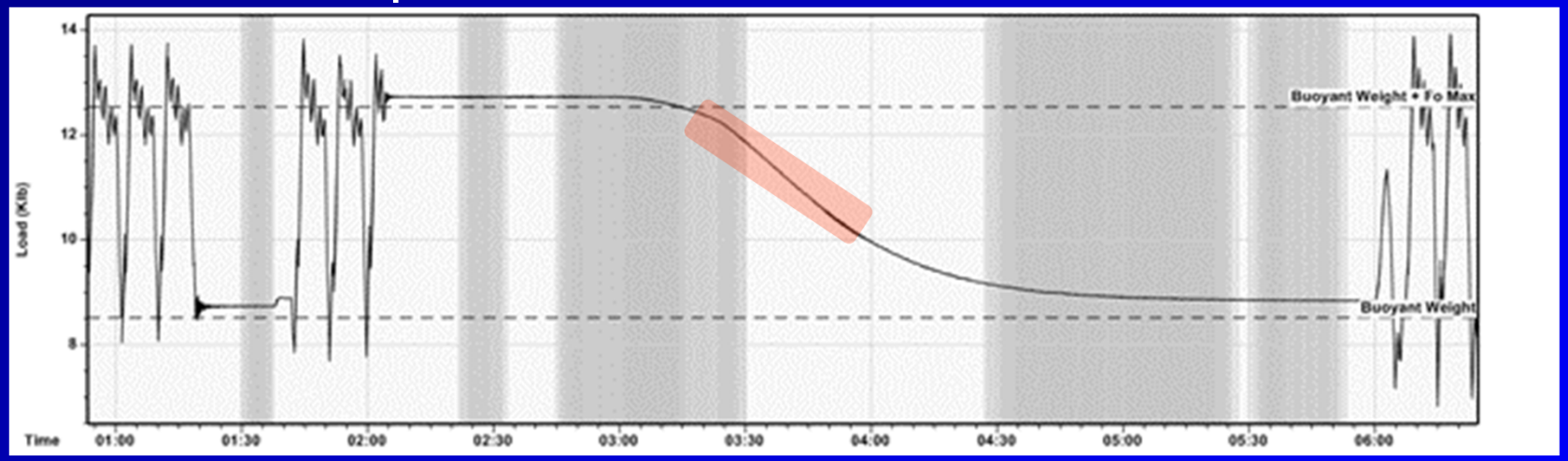
IMPORTANT NOTE:

BEFORE INITIATNG the CBE test the LAPTOP CLOCK (hours:minutes:seconds) and the operator's WATCH should be SYNCHRONIZED



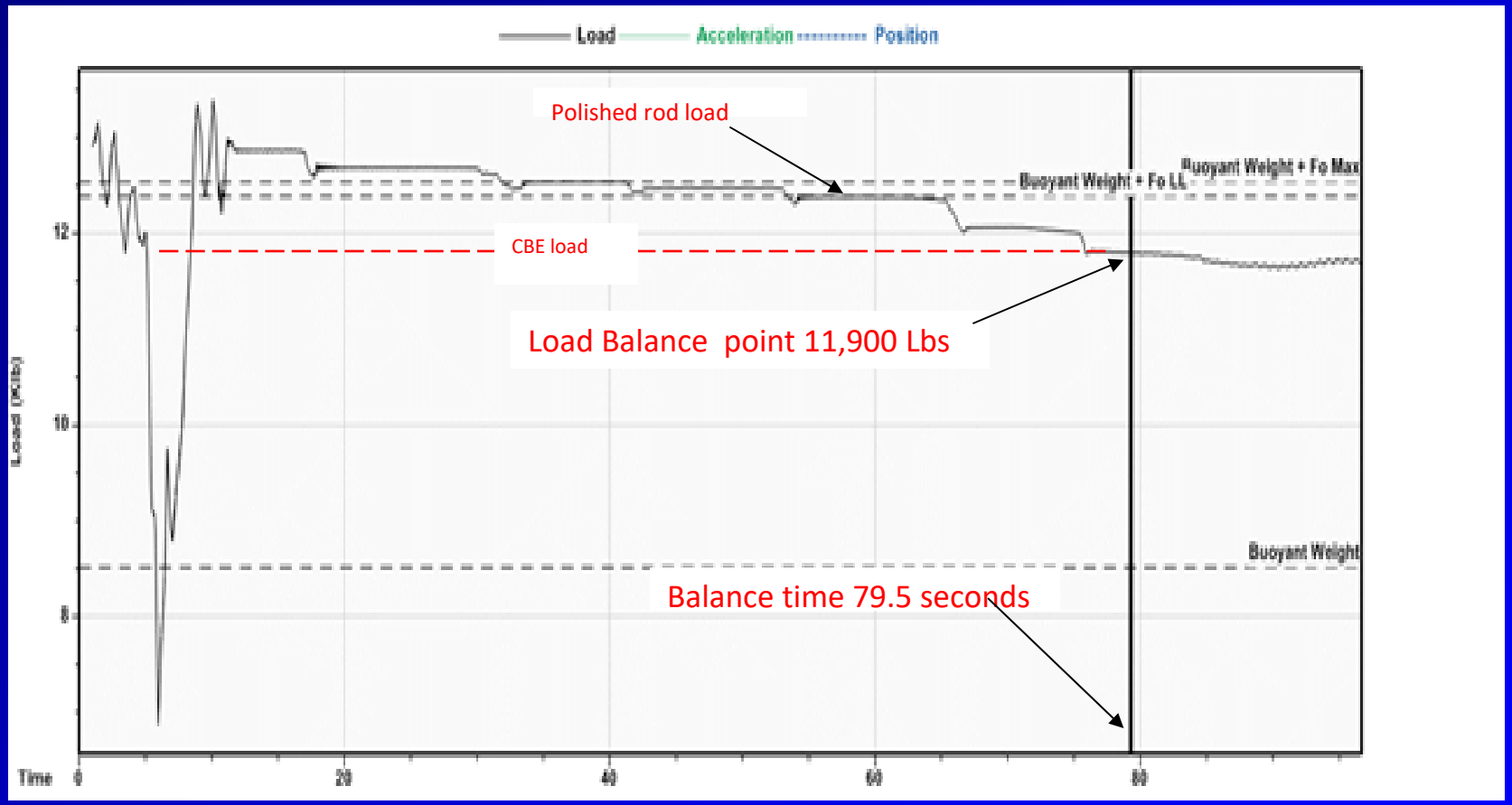
Recommendation

Prior to running the CBE test it is a good practice to run a SV/TV valve test that includes a long duration Traveling Valve Test to determine how quickly the polished rod load decreases.



As the polished rod load decreases due to slippage or valve leakage (highlighted section in the figure) there will be a point in time when this load momentarily balances the weight of the cranks so that if the operator releases the brake the cranks will not move. That load is the CBE load.

CBE Balance Load and Time

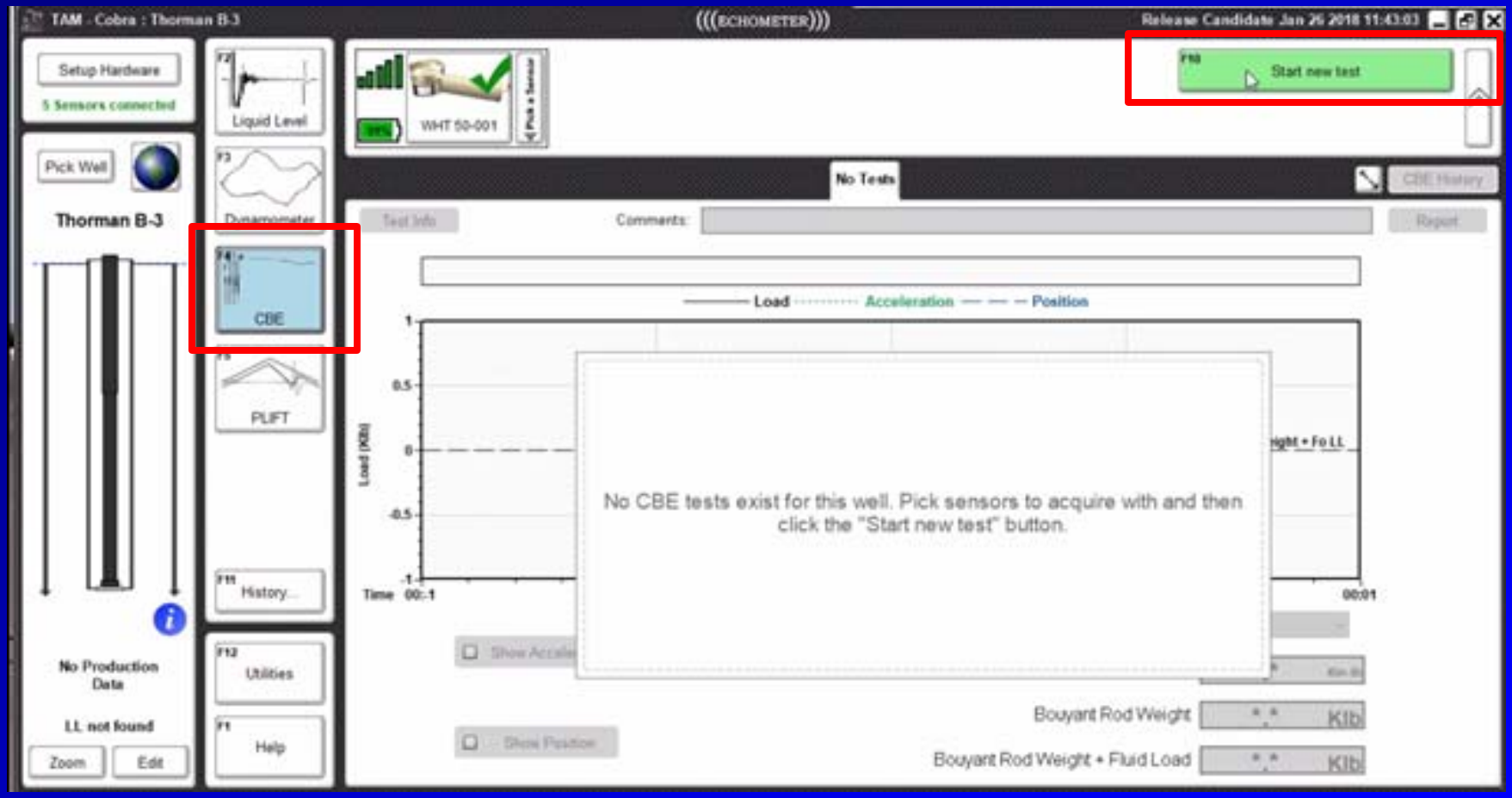


The polished rod load <u>momentarily</u> balances the weight of the cranks so that if the operator <u>releases the brake</u> the cranks will not move.

Static Counterbalance Effect (CBE) Test Procedure

1. Click CBE button then click “Start New Test” to start data acquisition and note the precise time when the key was pressed
2. Stop the unit on the upstroke with the cranks level.
3. Determine whether the polished rod load is greater or less than the counterbalance effect load
   - As drop in PR load occurs
   - Release the brake periodically to check for movement.
4. Cranks will balance momentarily as the load is equalized due to fluid leakage from the tubing into the pump.
5. The operator should record the precise time when the brake can be released without movement of the crank arm.

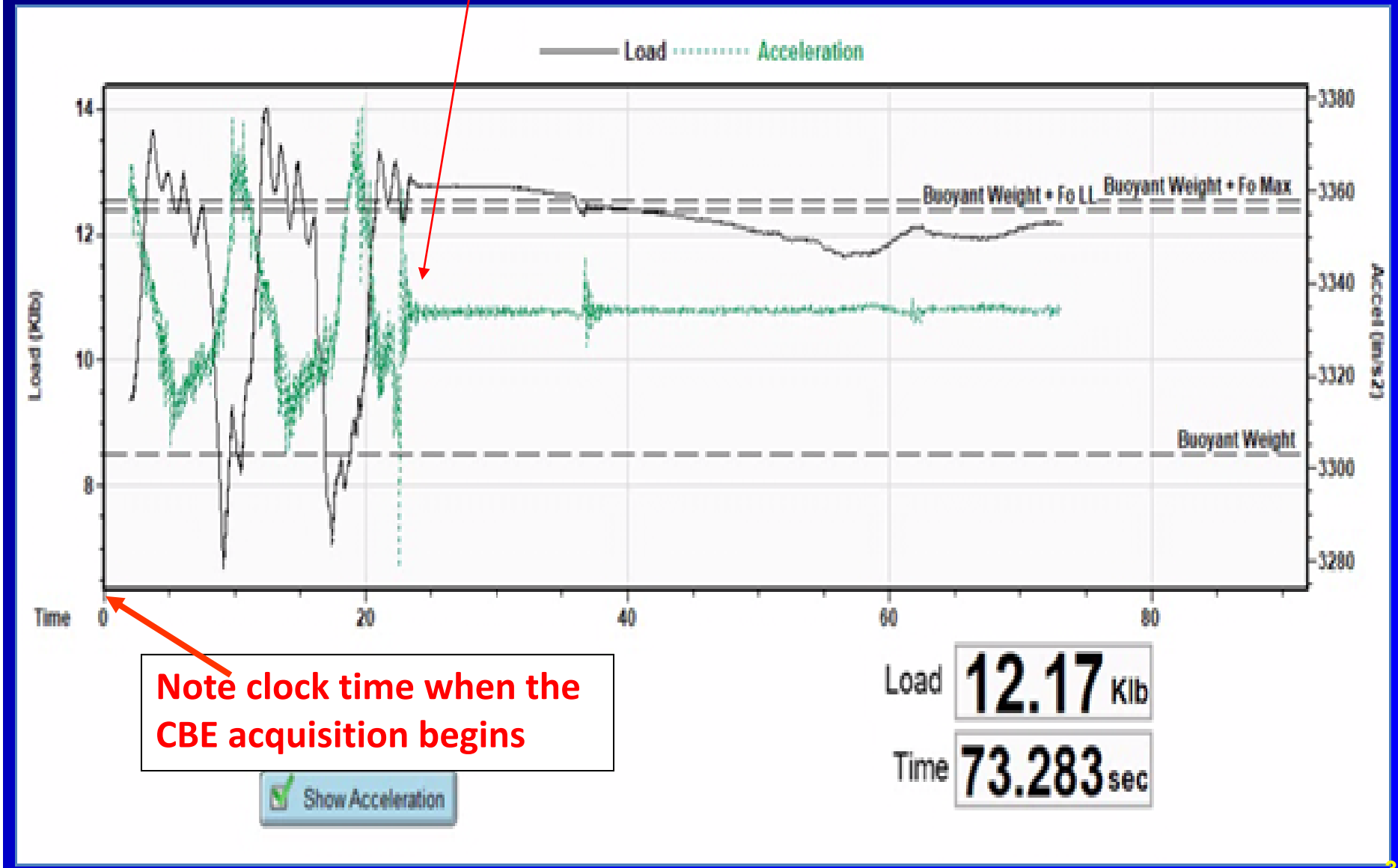
Stop Dyno & Select CBE Acquisition



Click CBE button then click "Start New Test" to start data acquisition and note the precise clock time (minutes and seconds) when the key was pressed.

Stop the unit on the upstroke with the cranks level.

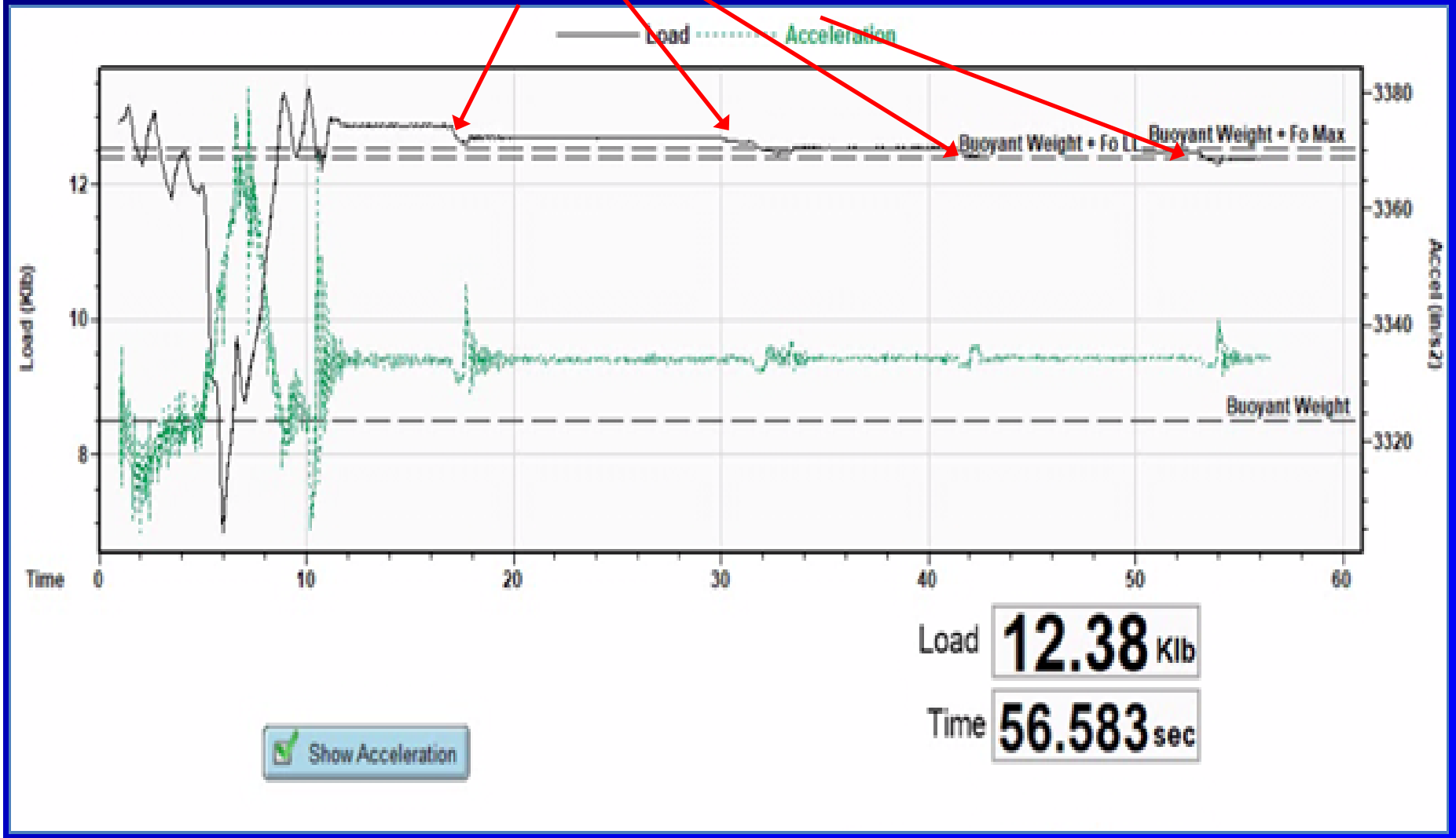
(Acceleration signal will stay constant.)



Note clock time when the CBE acquisition begins

Unit stopped on upstroke with cranks level

Release the brake periodically to check for movement of the crank



Load and acceleration record during CBE test

Load Balance Point

Cranks will balance momentarily when Polished Rod and CBE load are equalized

RECORD THE PRECISE TIME (hours, minutes and seconds) when the brake can be released without movement of the crank arm.

Recording of CBE Load When Balanced

Method to indicate to the TAM software the value of the CBE load depends on the hardware used for the test:

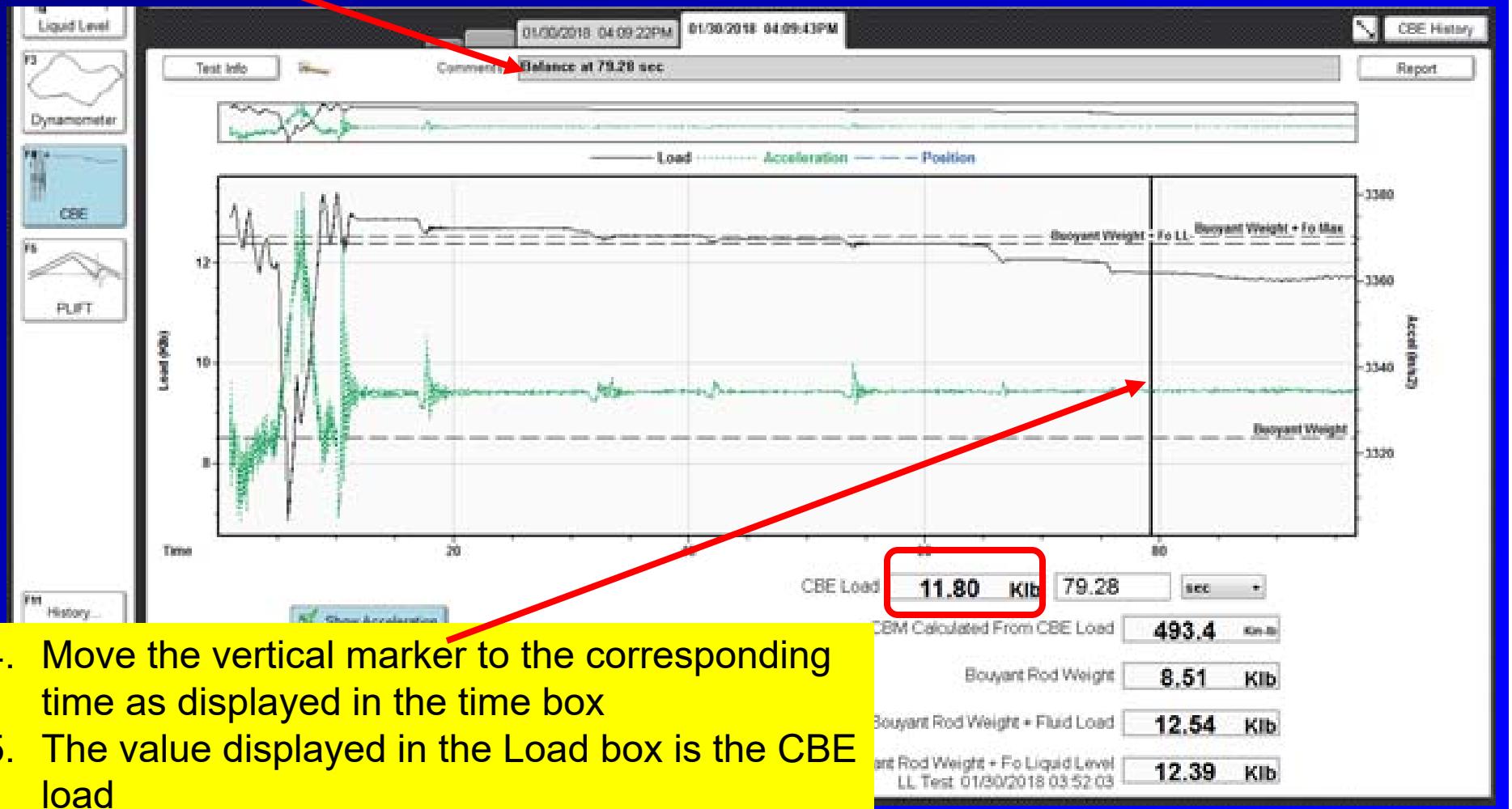
A. Wired Well Analyzer

B. Wireless Horseshoe only - NO WPRT

C. Wireless Horseshoe WITH auxiliary WPRT

A - WIRED WA - Recording of CBE LOAD

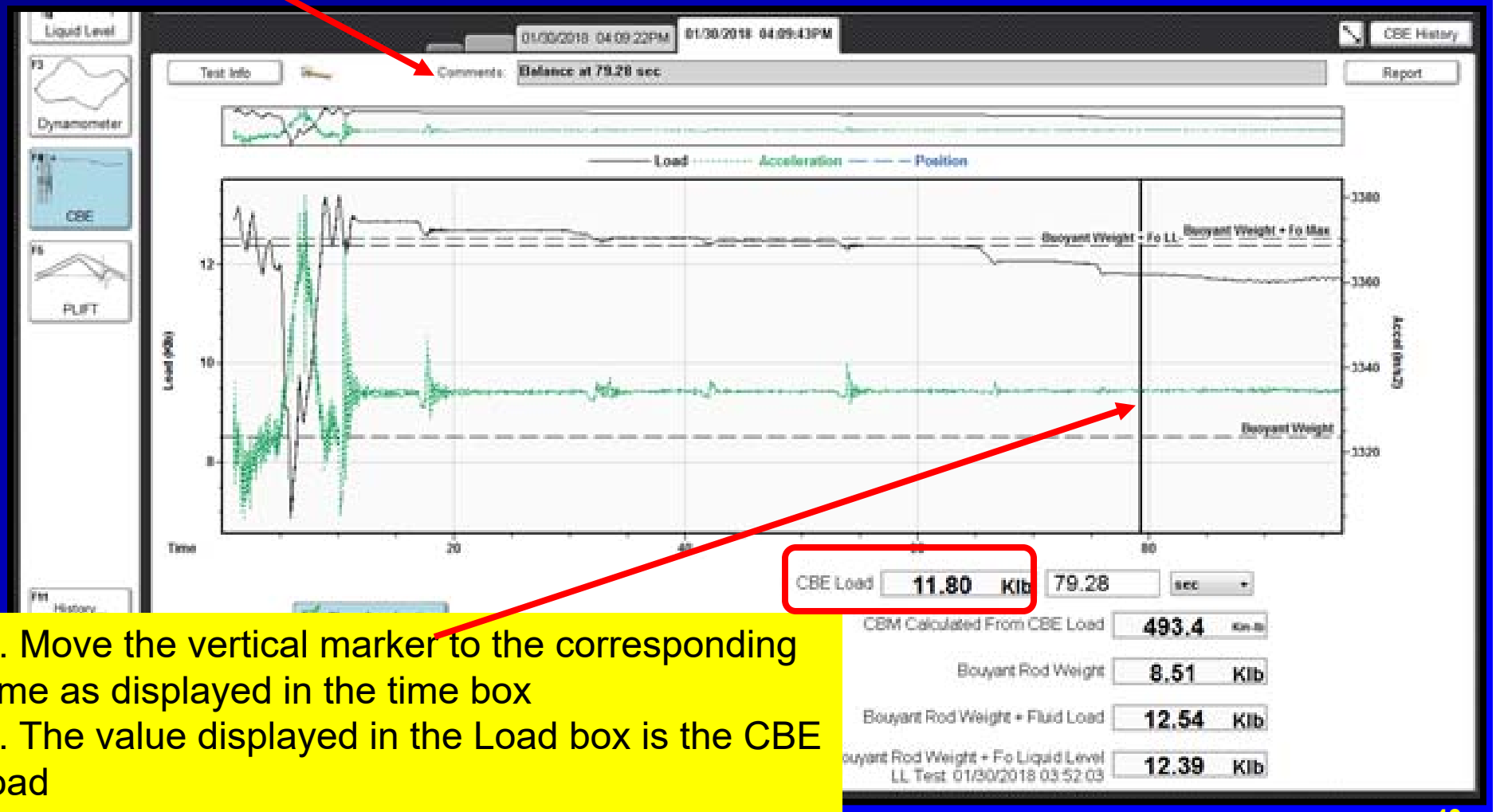
1. Note the exact clock time when the cranks did not move
2. Calculate the time (seconds) elapsed from the start of the CBE test.
3. Input this elapsed time when cranks balanced into the Comments field



4. Move the vertical marker to the corresponding time as displayed in the time box
5. The value displayed in the Load box is the CBE load

B – Wireless HT ONLY Recording of CBE LOAD

1. Note the exact clock time when the cranks did not move
2. Calculate the time (seconds) elapsed from the start of the CBE test.
3. Input this elapsed time when cranks balanced into the Comments field

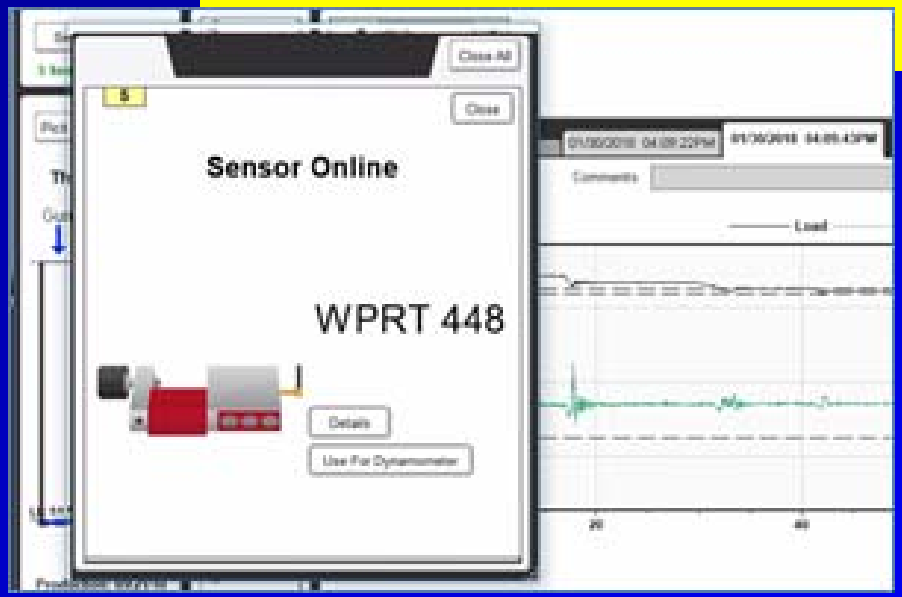


4. Move the vertical marker to the corresponding time as displayed in the time box
5. The value displayed in the Load box is the CBE load

C -Using a WIRELESS HT with WPRT On-Line

1) Make sure that the wireless PRT is turned ON and is listed as a FRIENDLY sensor BEFORE staring the CBE test.

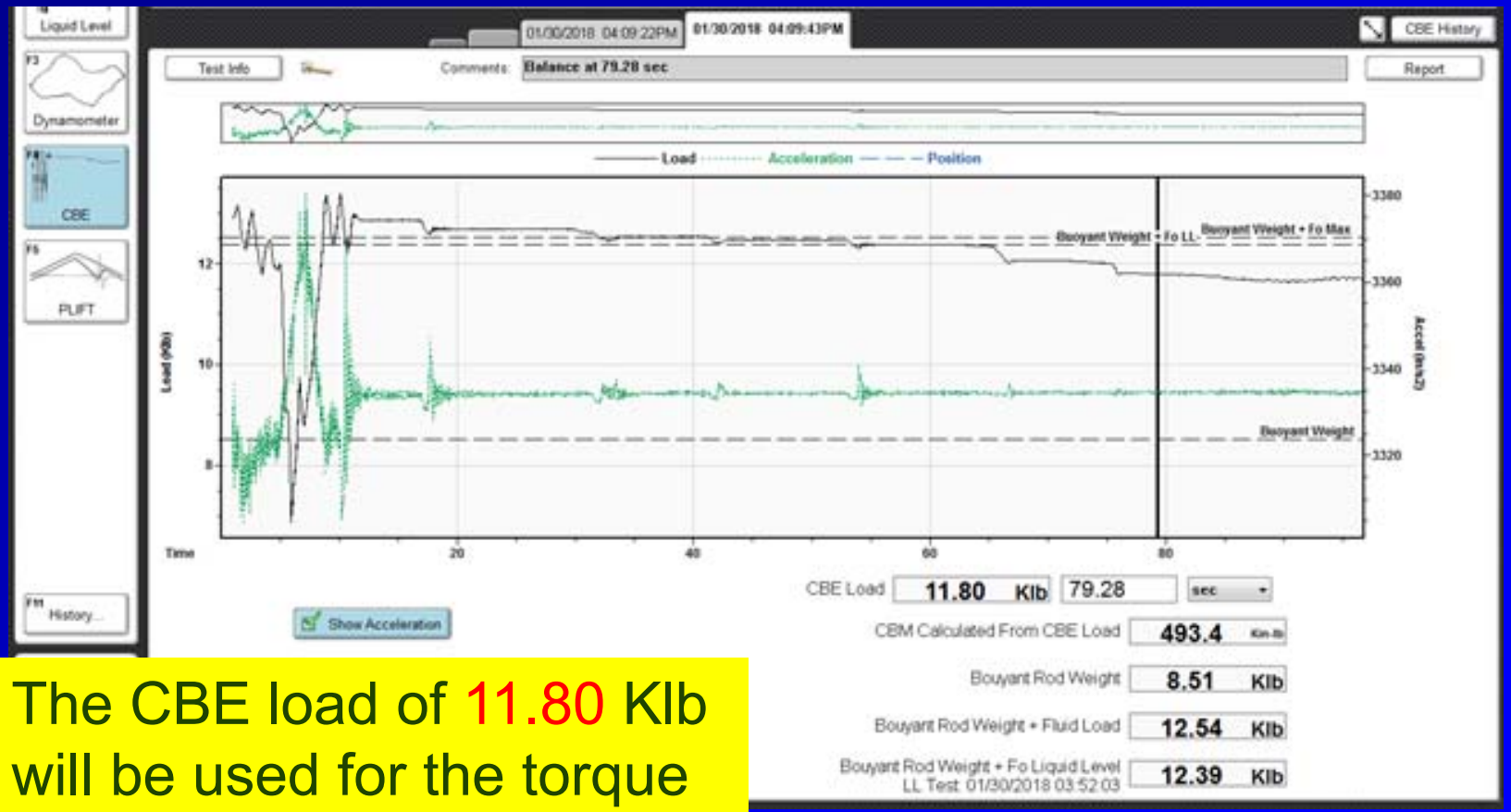
2) Press the Acquire Button on the WPRT when the crank balance point is detected when the brake is released.



WPRT Sensor Online will pop-up and TAM will remember the exact time when the button was pressed.

C –Continued ……. with WPRT On-Line

3 - When the CBE Stop Button is pressed the program will display automatically the marker line at the CBE equilibrium time



The CBE load of 11.80 Klb will be used for the torque calculations.

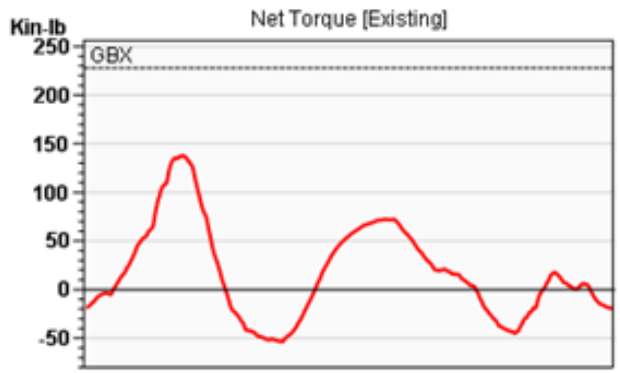
CBE Test Used for Torque Analysis

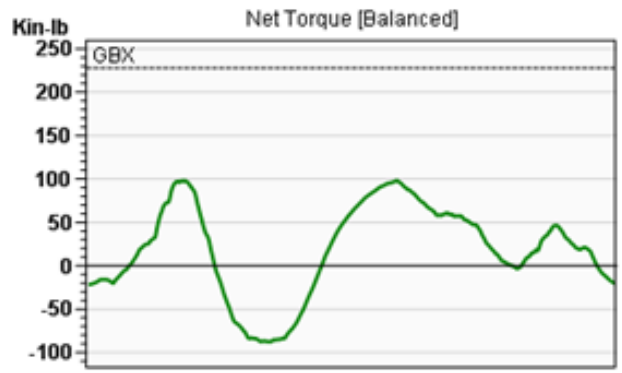
1. To determine the net gearbox torque loading of the torque reducer

2. To establish whether the unit's gearbox is properly balanced

3. To determine the movement of the counterweights, necessary to achieve a better balanced net gearbox torque on the pumping unit gearbox.

Moving Counterweights Results in Equal Peak Net Gearbox Torques on Up and Down Stroke





	Existing	In Balance
Min Gearbox Torque, Upstroke	-53.6 Kin-lb	-87.5 Kin-lb
Max Gearbox Torque, Upstroke	137.8 Kin-lb	98.1 Kin-lb
Min Gearbox Torque, Downstroke	-44.9 Kin-lb	-21.0 Kin-lb
Max Gearbox Torque, Downstroke	72.3 Kin-lb	98.1 Kin-lb
RMS Gearbox Torque	50.8 Kin-lb	55.7 Kin-lb
AVG Gearbox Torque	17.5 Kin-lb	18.5 Kin-lb
Cyclic Load Factor	2.904	3.009

Out of Balance	rod heavy
Maximum Counterbalance	*.* Kin-lb
Existing Counterbalance	493.4 Kin-lb
Required Counterbalance Increase	44.0 Kin-lb
To Balance Move 8.820 Klb weights OUT	4.99 in

For Net Torque Calculations Use

- CBM From Counterweights Database
  CBM: 621.2 Kin-lb CBE: 14.76 Klb
- CBE From CBE Test: 01/30/2018 04:09:43PM
  CBE: 11.80 Klb CBM: 493.4 Kin-lb

Use	Date/Time	CBE	CBM
☐	01/30/2018 04:01:53PM	12.36	517.6
☐	01/30/2018 04:07:13PM	12.39	518.8
☐	01/30/2018 04:09:22PM	13.16	552.1
☑	01/30/2018 04:09:43PM	11.80	493.4

Move Counterweights OUT 5 inches