# How to Maintain High Producing Efficiency in Sucker Rod Lift Operations

Lynn Rowlan

ECHOMETER

# What is High Efficiency?

## Electrical Efficiency

- Total System Efficiency Should be greater than 50%
- Surface Efficiency should be greater than 80%

## Mechanical Efficiency

- Pump, Rods, Pumping Unit Size and Balance

## Reservoir Producing Rate Efficiency

- Should be greater than 95%

# High Efficiency?

High ***electrical*** efficiency, ***mechanical*** efficiency and ***reservoir producing rate*** efficiency requires:

a) Measurement of motor power, dynamometer data, the liquid level depth with casing pressure and a representative well test.

b) (Electrical efficiency, mechanical efficiency and reservoir producing rate efficiency) All three must be high for the well to be produced at optimum conditions.

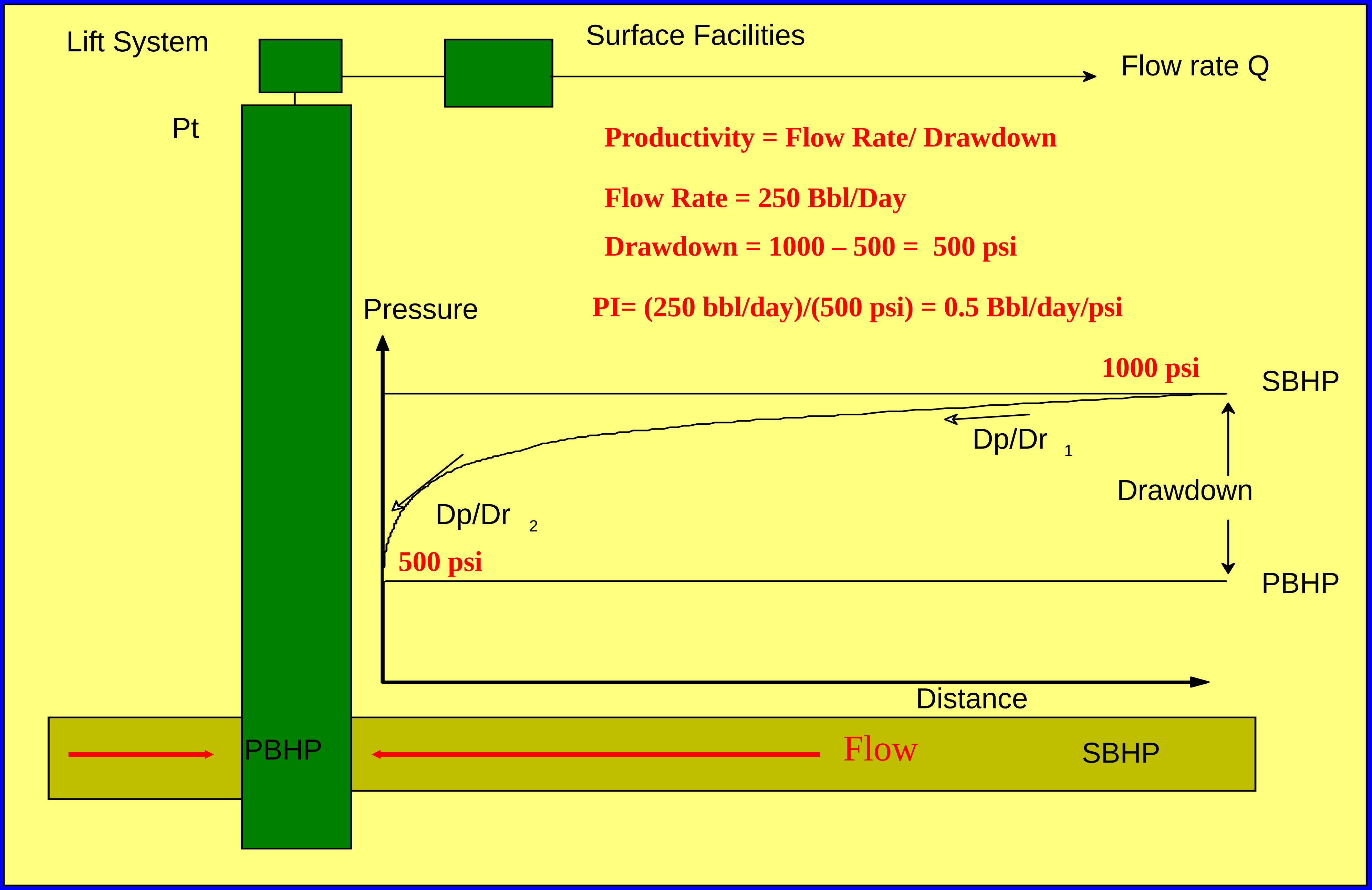
# What Should be Known in Order to Analyze a Well?

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

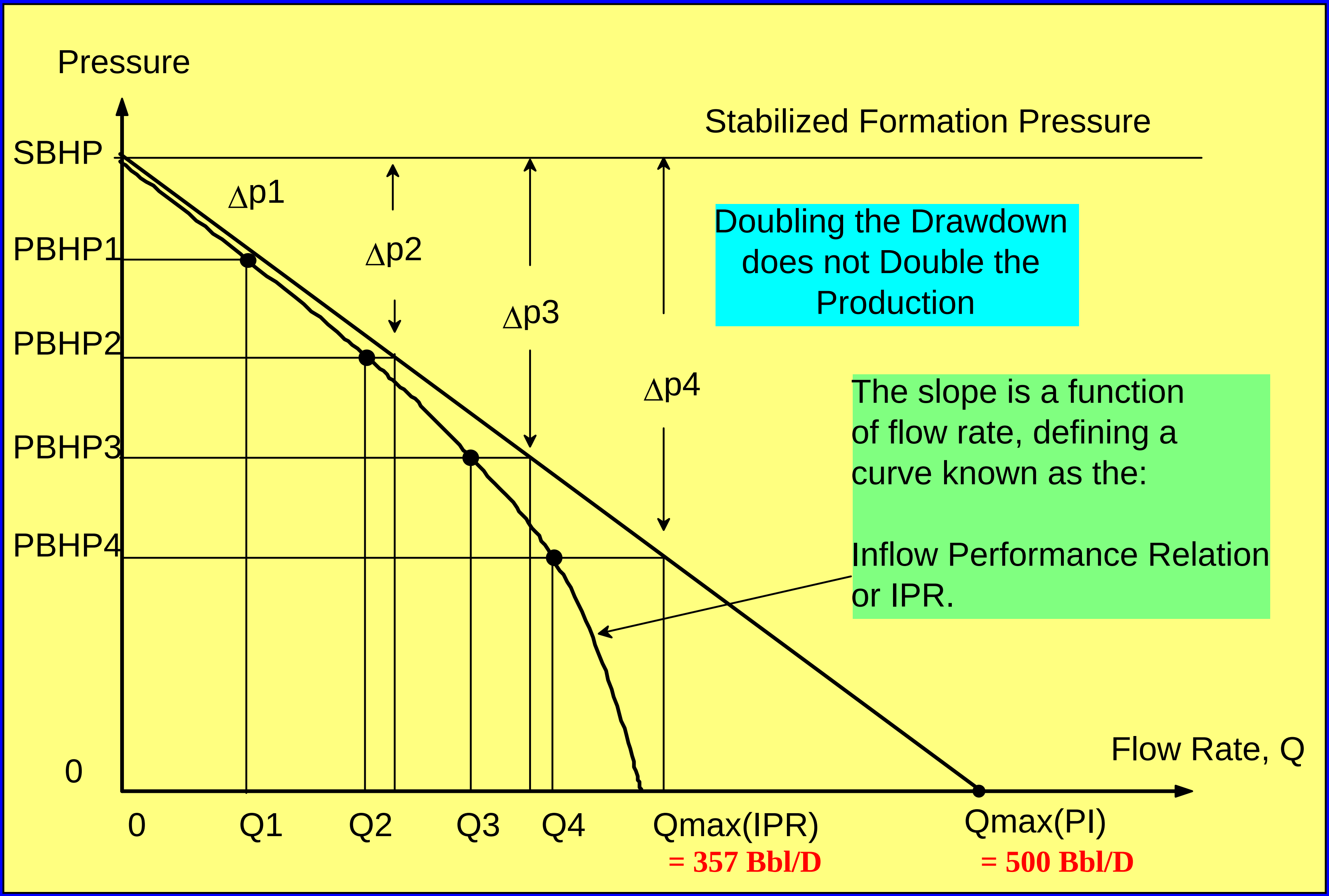
# Analyze Well
# To Determine Efficiencies:

1. Analyzes the well's inflow performance to determine if additional production is available. ( >95% Eff. )
2. Determines the overall electrical efficiency.
3. Analyzes the efficiency of the pump.
4. Analyzes the efficiency of the down-hole gas separator.
5. Analyzes the mechanical loading of rods and pumping unit.
6. Analyzes performance of prime mover.

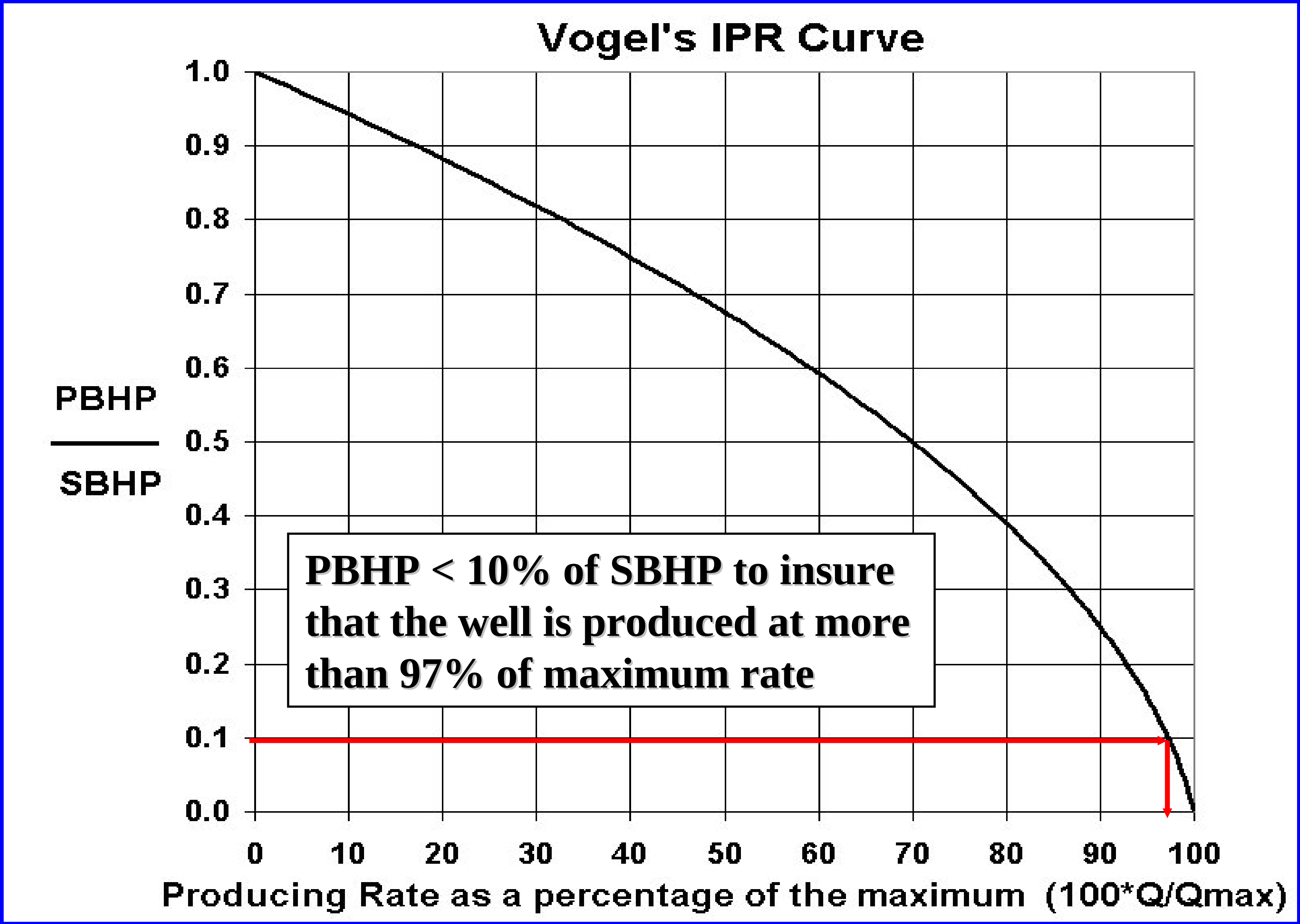
# Well Flow Mechanism



# Determine Well's Potential using Inflow Performance



# Vogel IPR Relationship

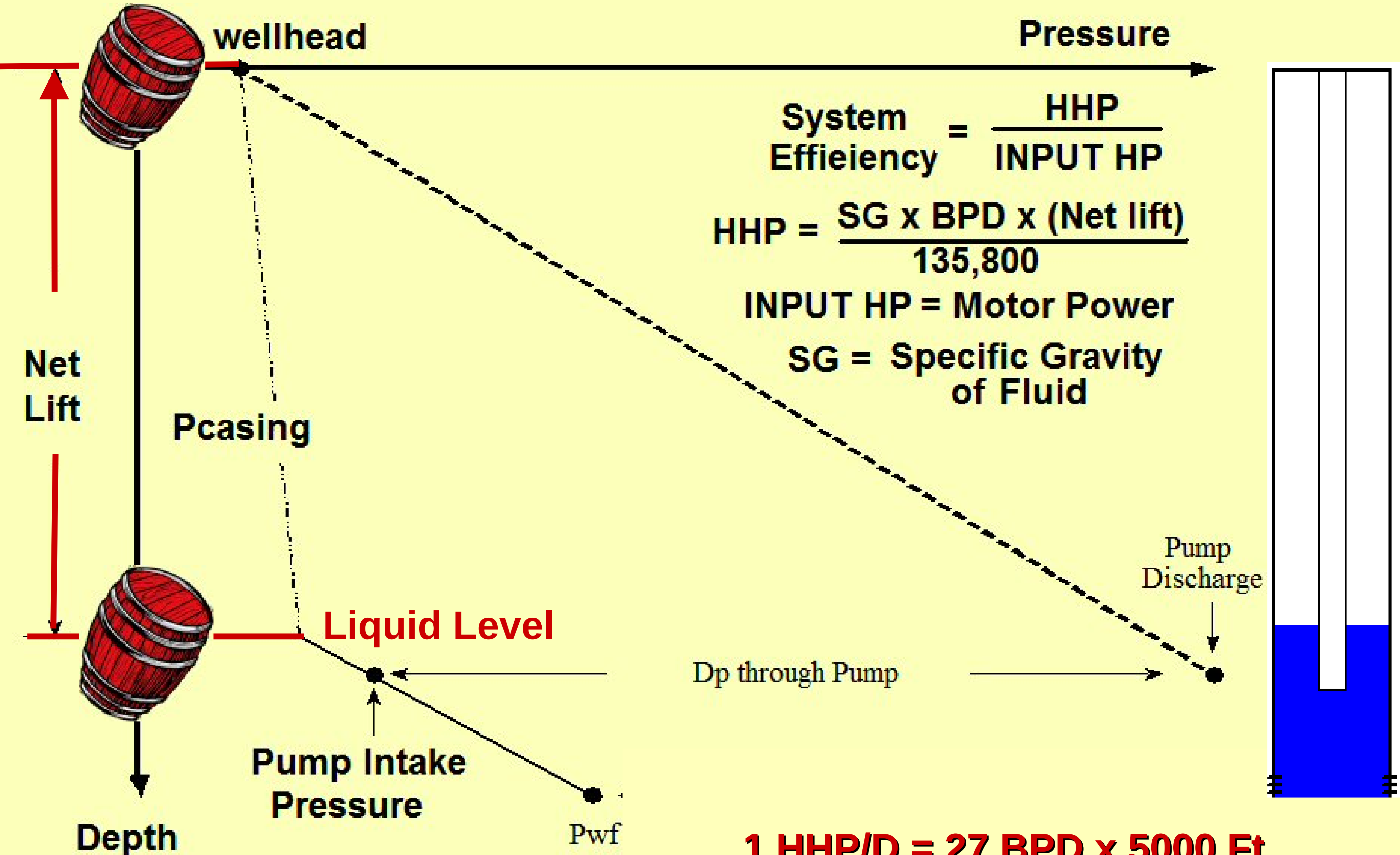


# Electric Power (kW) and Current (Amps) Input to the Motor over the time of One Pump Stroke

# Efficiency

1. Power Input into Sucker Rod Lift System
   a) System Does Work to Add Energy to Fluids
   b) Fluids then flow to the Surface
2. Discuss Surface & System efficiency
3. Use Fluid Level, Dynamometer, and Power Surveys to Determine Efficiency
4. Low Efficiency Used to Identify Problems
5. How to maintain a high producing efficiency in sucker rod lift operations

# Net Lift ~ System Efficiency Equation




$$\text{System Effieiency} = \frac{\text{HHP}}{\text{INPUT HP}}$$

$$\text{HHP} = \frac{\text{SG x BPD x (Net lift)}}{135{,}800}$$

INPUT HP = Motor Power

SG = Specific Gravity of Fluid

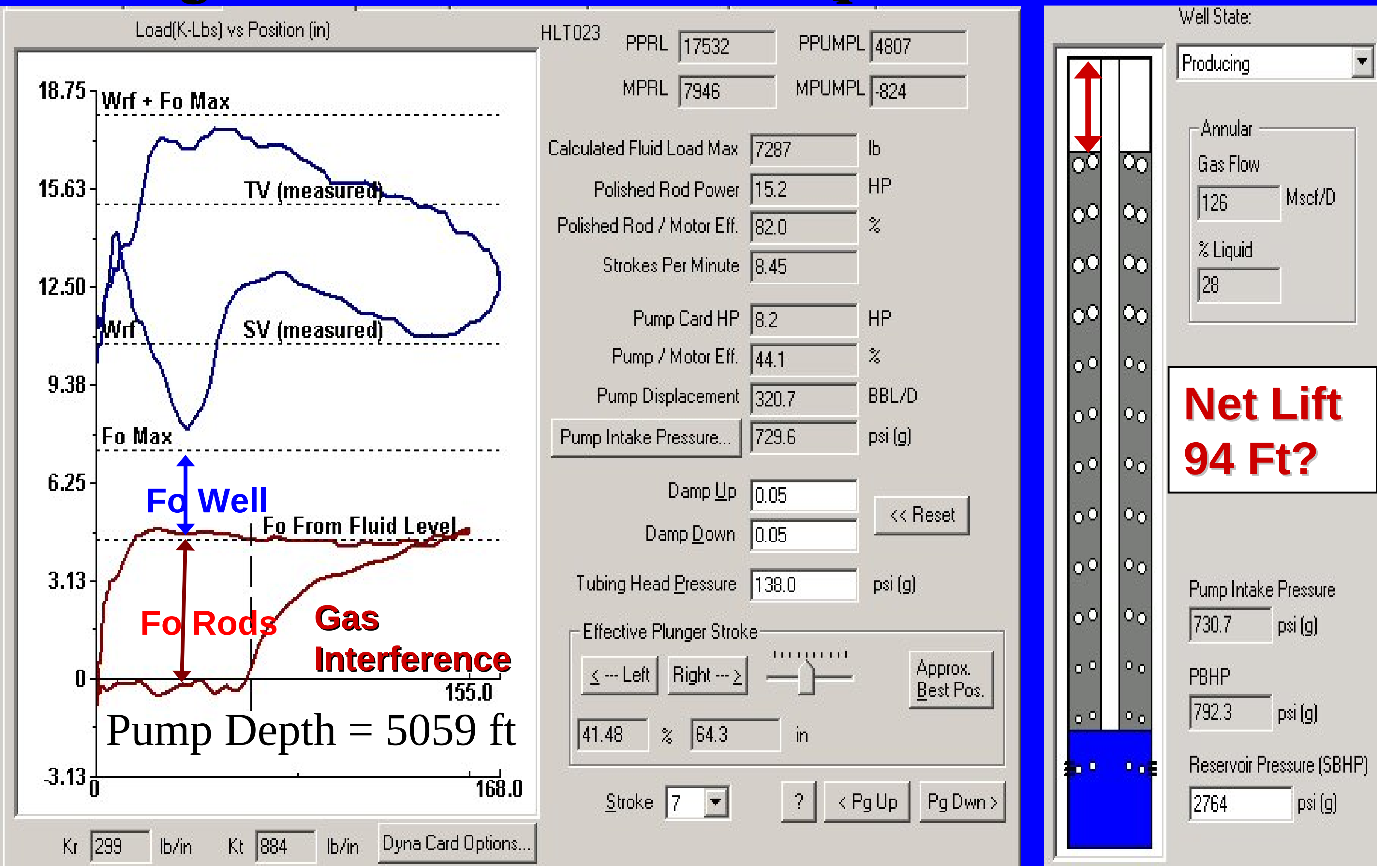
**1 HHP/D = 27 BPD x 5000 Ft**

# Measure Motor Input = 13.9 kW

Acquire:

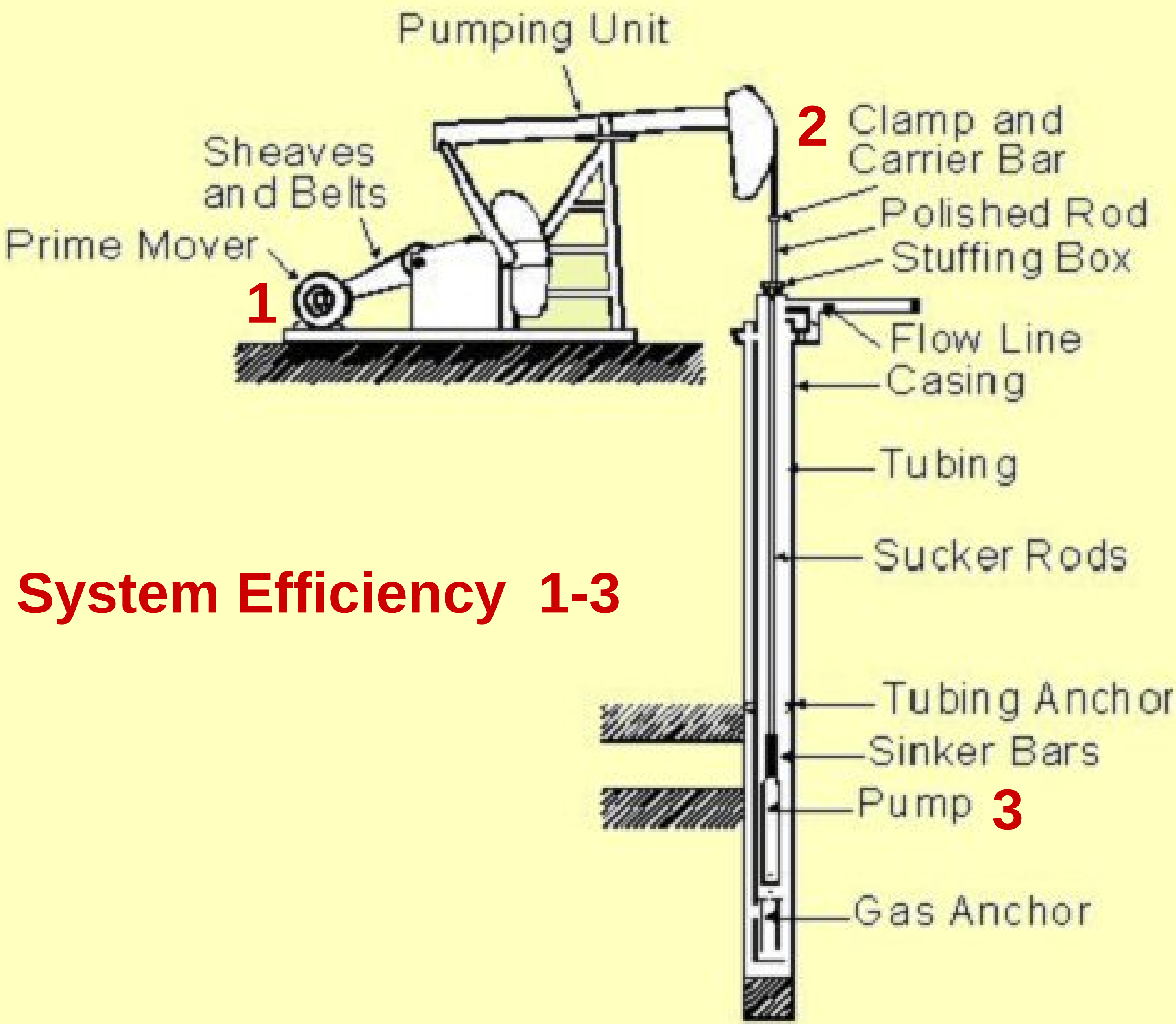
- RMS (thermal) motor current
- Average (real) motor current
- kW during a pump stroke cycle.


# Pump Intake Pressure = 730.7 Psig 133 BOPD
# Tubing Fluid Gradient = 0.335 psi/ft 241 BWPD



$$\eta_{system} = \frac{(Q,_{BPD})\,(Depth - PIP/.433 \times SG)\,(SG)\,(7.368\,E\text{-}06)}{(Kw / 0.746)}$$

**Surface Efficiency 1-2**




**System Efficiency 1-3**

**Determine:**

1. **Input Kw**
2. **PR Hp**
3. **Pump Hyd Hp**

# System Efficiency Calculation

Theoretical amount of work required to lift the liquid from the intake pressure at the pump to the surface divided by the energy supplied to the motor.

Measure:

- Pump Intake Pressure from Acoustic Liquid Level

Net Lift = P Depth–PIP/ .433xSG

= 5059 – 730/0.335 = *2880 ft*

- Fluid Volumes and Properties
- Motor Input Power Measurement

# 55% System Efficiency

Overlay | Dyna Cards | Torque | Rod Loading | Load/Current | Power Torque | Power Results | Ana

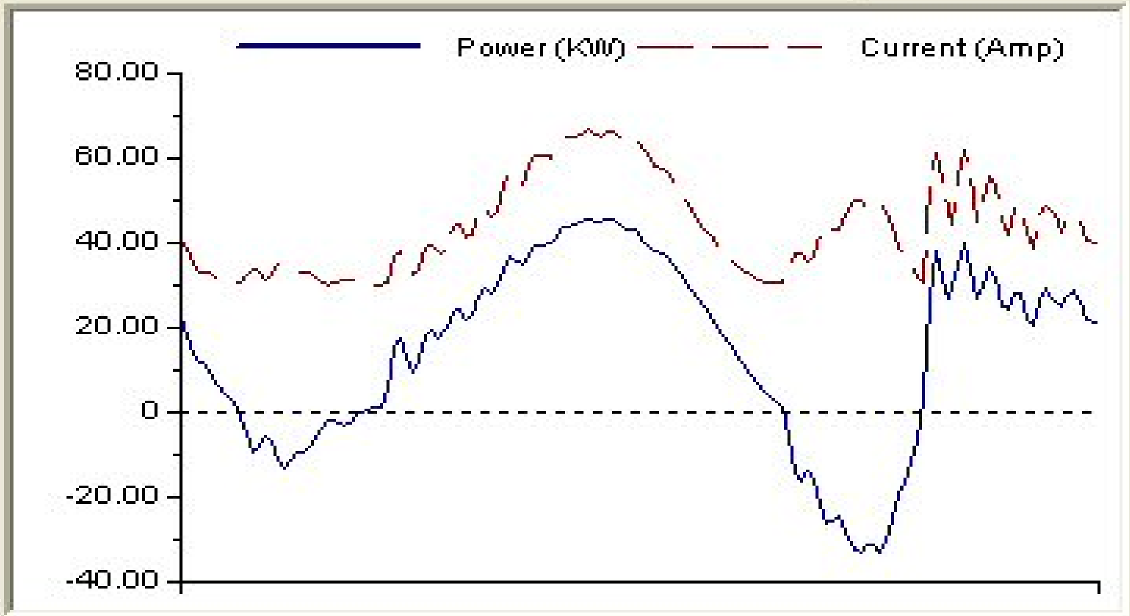
Monthly Operation Costs (30 Days per Month):

| | | |
|---|---|---|
| Run Time | 24 | hr/day |
| Cost With Gen. Credit | 349.96 | $ |
| Cost No Gen. Credit | 453.69 | $ |
| Demand Cost | 176.96 | $ |
| Oil Prod. Cost | 15.8 | ¢/bbl |
| Liquid Prod. Cost | 5.6 | ¢/bbl |
| Oil Production | 133 | BBL/D |
| Water Production | 241 | BBL/D |

| | | |
|---|---|---|
| Recommended Minimum NEMA D Motor | 24.8 | KW |
| Rated HP | 44.76 | KW |
| Rated Full Load AMPS | 75 | |
| Thermal AMPS | 45.1 | |
| Gross Input | 18.0 | KW |
| Net Input | 13.9 | KW |
| Demand | 22.1 | KW |
| Average | 20.1 | KVA |

Average Power

| | | |
|---|---|---|
| With Generation Credit | 13.9 | KW |
| No Generation Credit | 18.0 | KW |
| Avg. Power Factor | 56.4 | % |
| System Efficiency | 55.0 | % |




Stroke 6 | ? | < Pg Up | Pg Dwn >

# Why is Efficiency a Useful Benchmark?

- Measure of work input (power requirements) relative to useful output (liquid production).
- Directly related to operating costs
- Relatively easy to measure
- Generally accepted guidelines

## Efficiency

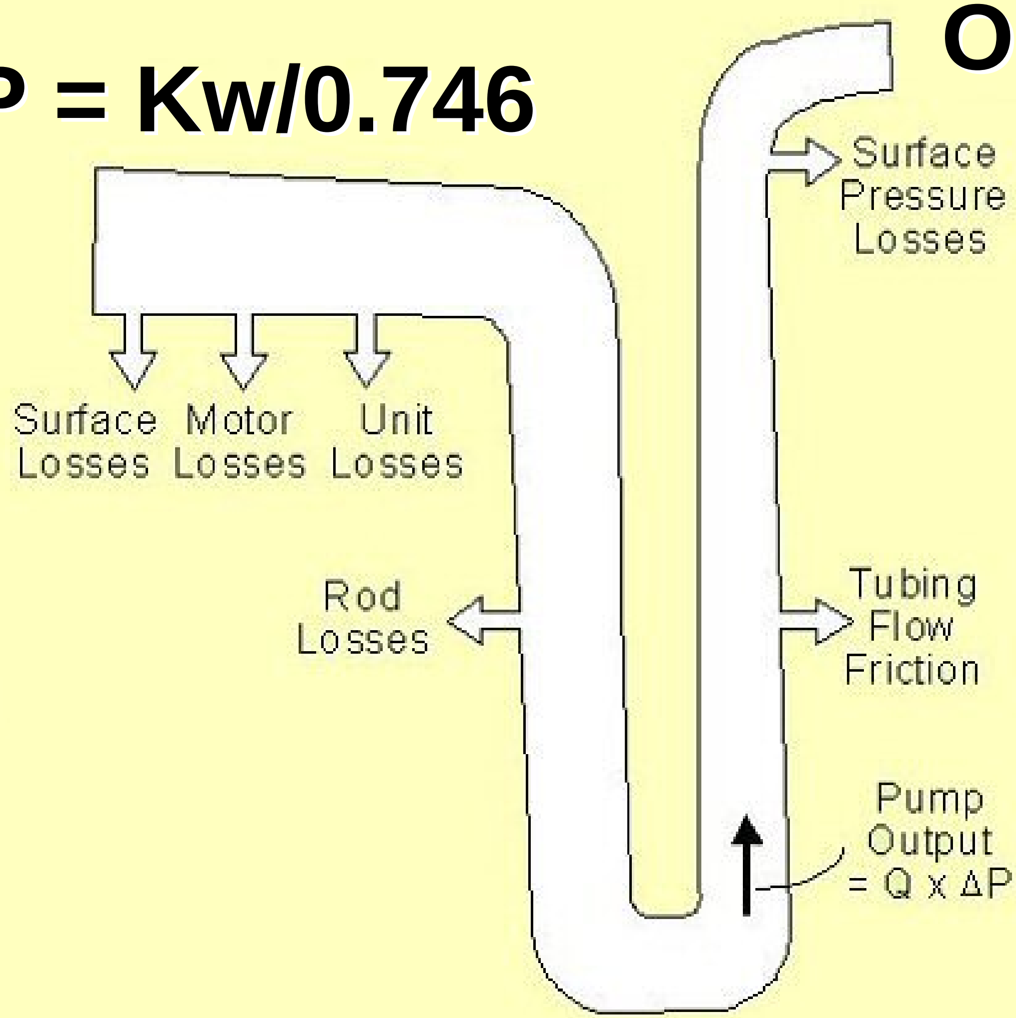
- **System Efficiency should be > 50%**
- **Surface Efficiency should be > 80%**

# Losses ~ System Efficiency

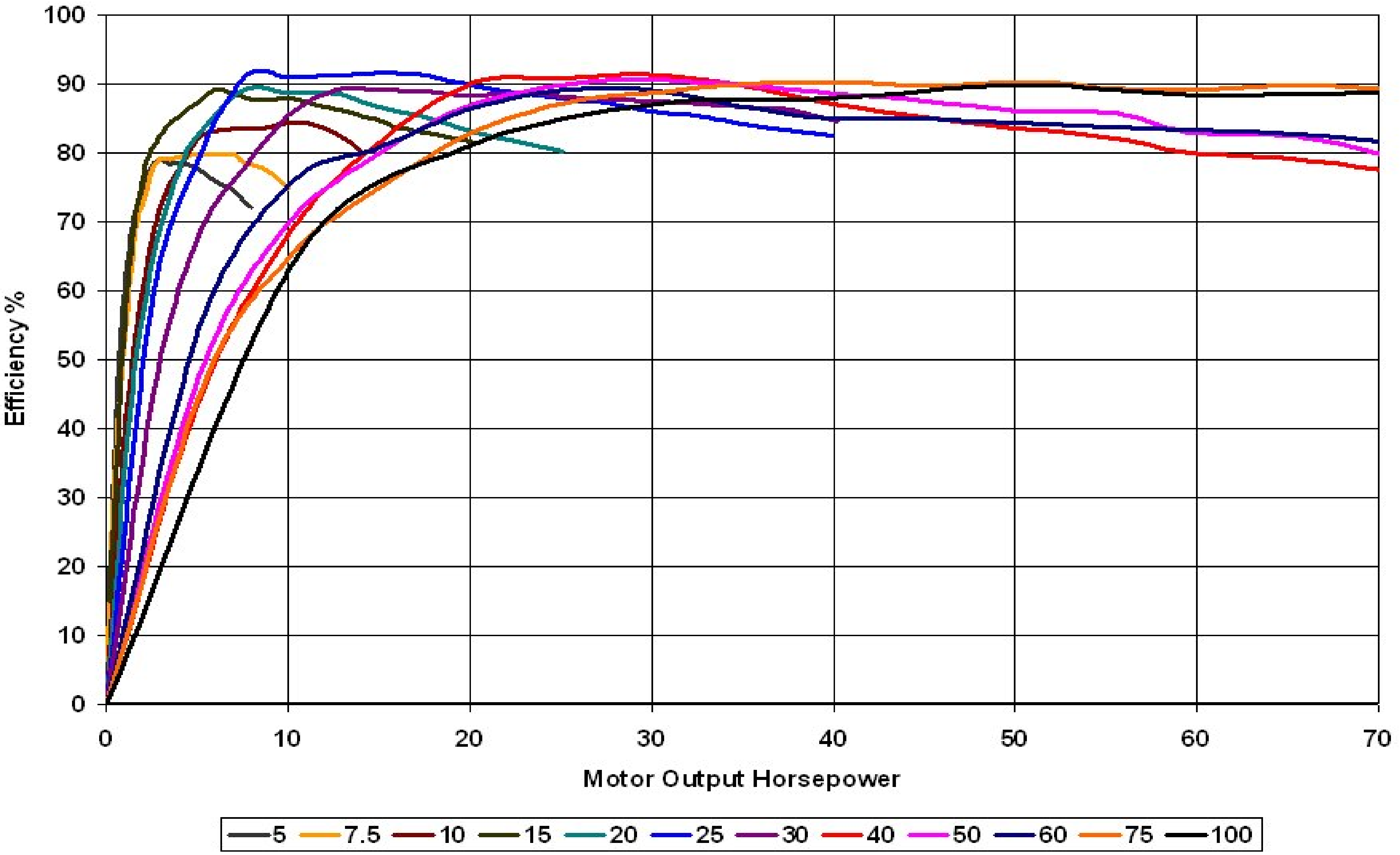
$\eta_{BEAM,\ system} = \eta_{surface}\ \eta_{motor}\ \eta_{unit}\ \eta_{rods}\ \eta_{tubing\ friction}\ \eta_{surface\ pressure}$

**Input HP = Kw/0.746**

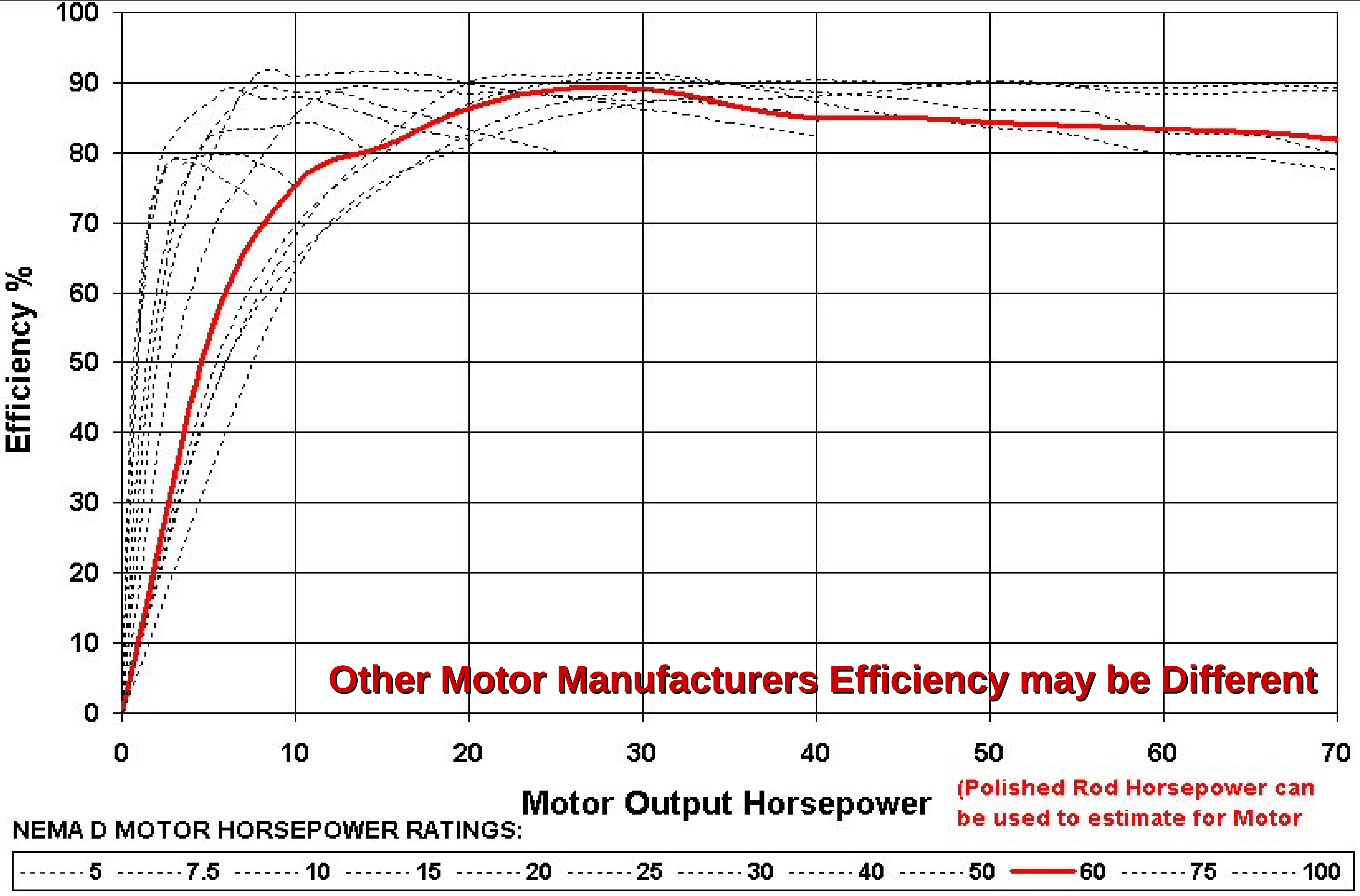
**Output**



# Motor Performance Data – Efficiency vs. Output Hp
# Comparison of NEMA D Motors



# 60 Hp NEMA D Motor (Surface Efficiency)
# Motor Performance Data – Efficiency vs. Output Hp

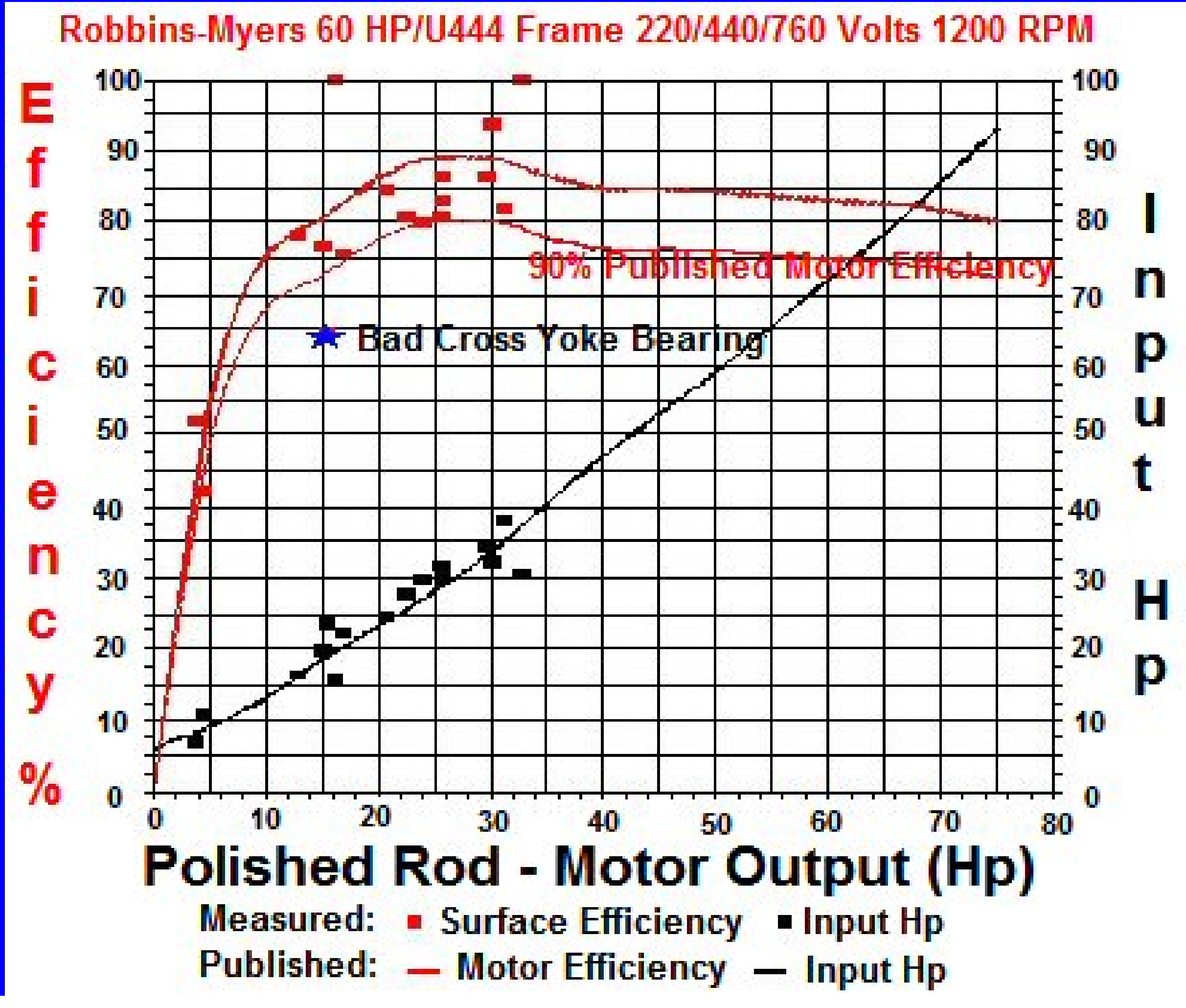


# Motor Performance –NEMA D Motors Minimum Surface Efficiency

| Motor HP - NEMA D | 5 | 7.5 | 10 | 15 | 20 | 25 | 30 | 40 | 50 | 60 |
|---|---|---|---|---|---|---|---|---|---|---|
| Motor Efficiency (30%-80%) Load | 78 | 80 | 84 | 85 | 88 | 91 | 88 | 91 | 90 | 86 |
| Minimum Surface Efficiency | 70 | 72 | 76 | 77 | 79 | 82 | 79 | 82 | 81 | 77 |

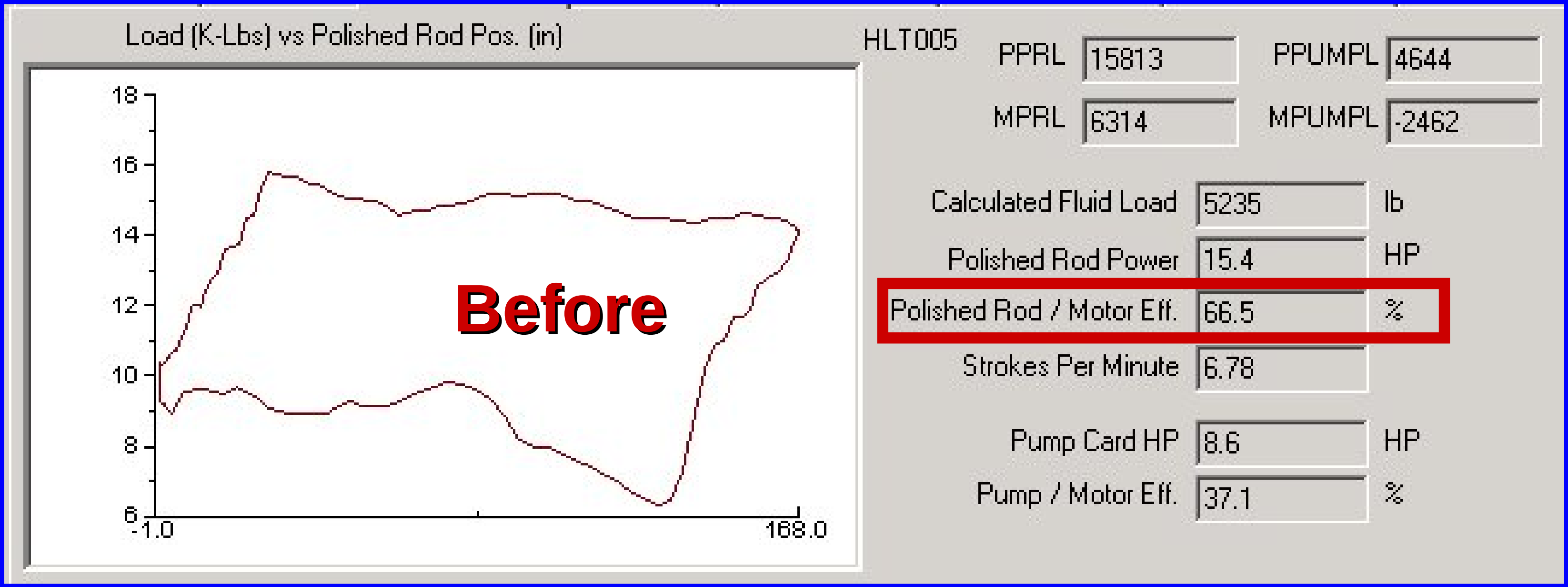
***Surface Efficiency*** **measured over one revolution of the crank is an excellent indicator of the operating performance of the surface equipment.**

***Surface Efficiency*** **includes losses per crank revolution in wirelines, structural bearings, transmissions, V-belts, and the electric motor.**

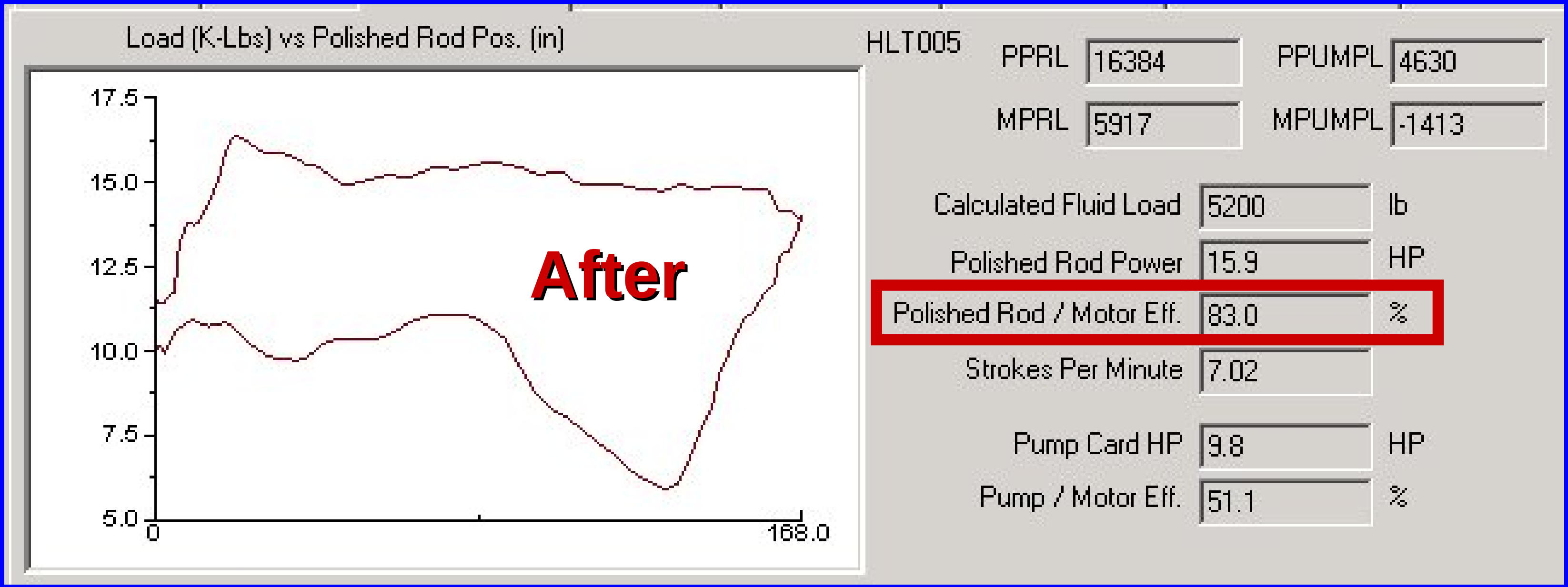


# Example of Low Surface Efficiency

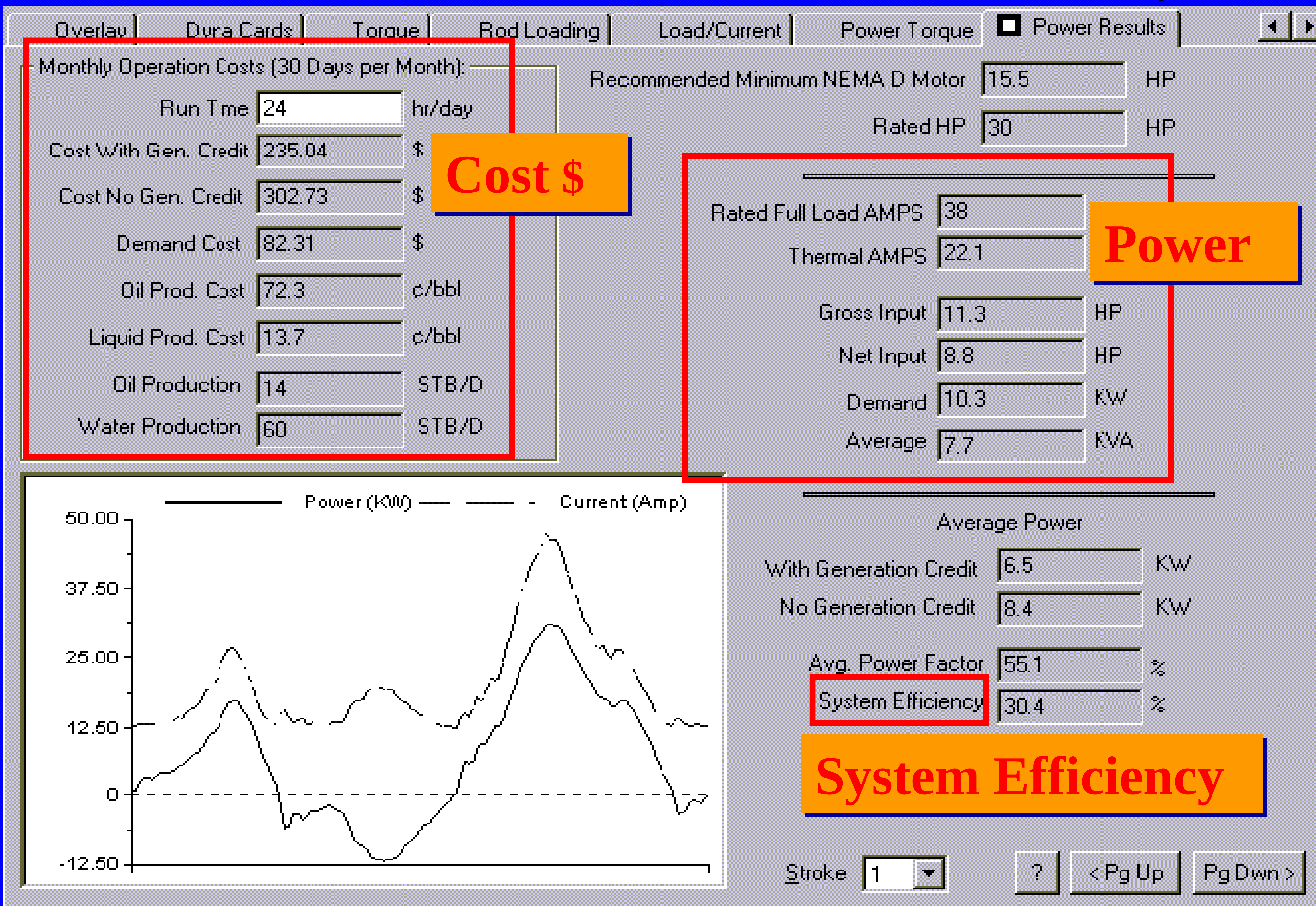
Bad Tail Bearing Resulted in Low Surface Efficiency of ***66.5%***



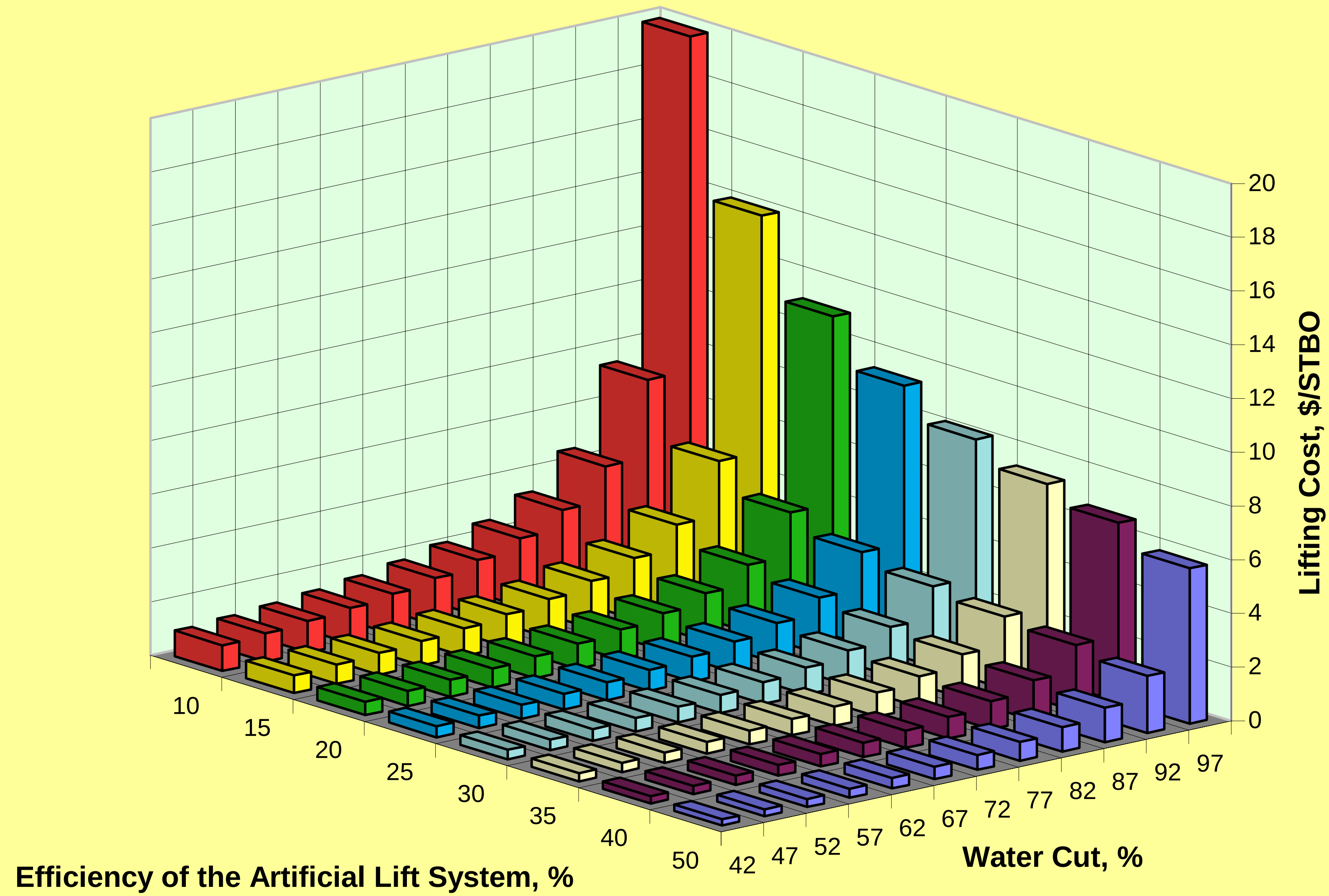

Surface Efficiency of ***83.0%*** After Repair of Bad Tail Bearing



# Motor Power and Electrical Analysis



# Oil Lifting Cost, 8000 ft net lift, $ 0.05/kwh
# Water Disposal Cost, $ 0.07/Bbl



# Use Both Producing Fluid Level Survey and Dynamometer Analysis to Answers the Following Questions:

1. Is the well being produced at its maximum production rate?
2. Does a fluid column exist above the pump intake?
3. Is the pump completely filled with liquid?
4. Is ***low efficiency*** caused by incomplete pump fillage due to over-pumping the well or due to gas interference?

# Acoustic and Power Surveys Show System Efficiency Less Than 35%

| | | | |
|---|---|---|---|
| Drawdown → | Low Producing BHP or Low Fluid Level | Low Producing BHP or Low Fluid Level | High Producing BHP or High Fluid Level |
| Dynamometer → | Pump Full | Low Pump Fillage | Low Pump Fillage |
| Your Job → | Low Priority Study Surface Efficiency *Tubing Leak ?* | *Potential to Improve Study Control Run Time* | *High Priority Study Gas Interference* |

# Acoustic and Power Surveys Show System Efficiency Greater Than 35%

| | | | |
|---|---|---|---|
| Drawdown → | Low Producing BHP or Low Fluid Level | High Producing BHP or High Fluid Level | High Producing BHP or High Fluid Level |
| Dynamometer → | Pump Full | Pump Full | Low Pump Fillage |
| Your Job → | Well OK | *Potential to Improve Study Pump Capacity* | *High Priority Study Gas Interference* |

# Low Efficiencies of Sucker Rod Lifted Wells Are Often Caused by Partial Pump Fillage

- **More efficient operations and lower electrical power usage will result if wells are operated with a <u>pump filled with liquid</u>.**

- **Full pump fillage also requires an <u>efficient downhole gas separation</u> that results in a full pump if sufficient liquid is present to fill the pump.**

- **Full pump fillage generally requires <u>controlling the run time</u> of the pumping unit to match the pump capacity to the maximum well inflow rate.**

# HOW TO MINIMIZE ELECTRICITY USAGE?

- Maintain a high pump volumetric efficiency:
  - Match pumping unit capacity with wellbore inflow.
  - Pump a Full Stroke of liquid by controlling run time with a POC or Timer
  - Eliminate Gas interference.
- When System Efficiency is low, find and fix problem.
- Mechanically/Electrically balance pumping unit.
- Properly size pumping unit, rods and pump to match well loads.
- On severely over-sized motors where surface efficiency falls below 50%, reduce motor size.

# Periodically Monitor Well's Operations To Maintain Efficient Operations

1. Check pump for proper operation

2. Produce all available liquid from the Wellbore

3. Operate well with high volumetric pump efficiency

4. Use POC or TIMER to reduce run time if pump capacity exceeds production rate

# High Efficiency Reduces Equipment Operating Costs

1. Uniform loading of pump and pumping unit reduces maintenance.
2. Operating the pumping unit a portion of the time subjects the unit to less wear and tear.
3. Fluid pound should be minimized.
4. Reduced shock loading results in decreased rod buckling, pump wear, tubing wear, excessive rod loading changes and pumping unit vibration.
5. Reduction of shock loading reduces maintenance costs.

# Maintaining High Efficiency in Sucker Rod Lift Operations Results in:

1. **Reduced Electrical Costs**
2. **Reduced Mechanical Operating Expense.**
3. **Increased in Oil and Gas Production.**
4. **Longer Run Times Before Failure.**

# Questions?