

Continuous Monitoring of Pump Efficiencies

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How we got to this discussion ...

- We entered into this area of study as a secondary effort while focusing on issues related to improved process control.
- Current SCADA technology allows for a facility oriented Pump Station energy analysis.
- Energy rate changes over the past two years have forced most utilities to re-adjust budgets.

Did you know?

- Annual cost of Operating a Booster Station with a 60hp pump with a typical 50% overall efficiency and a 25% (~40hr/week) duty cycle. {*\$9,671}
- Cost of operating the same station, improving the efficiency 10% {*\$8,059 saving \$1,612}
- New construction is capable of greater than 70% overall efficiencies in pump operation.
- * based on \$0.082/kW-hr for 480/277V service

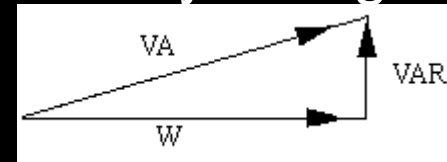
Examples of Operating Costs* 60hp motor application

Efficiency	70%	60%	50%	40%
Duty Cycle	25%	25%	25%	25%
Daily Cost	\$ 18.93	\$ 22.08	\$ 26.50	\$ 33.12
Annual Cost	\$ 6,908	\$ 8,059	\$ 9,671	\$ 12,088

* based on \$0.082/kW-hr for 480/277V service

Energy Efficiencies we Anticipated

- Use of Power Factor Correction Capacitors to reduce Utility charge



- Premium Efficient Motors (> 94%)
- Generator and ATS integration to the control system to optimize use
- Managing the Heating load while still keeping the operators happy (warm).

Some things we did not expect.

- Cost of keeping the generator block heater running.
- Efficiencies lost associated with piping design
- Operational costs related to valve selections
- Discovery of inefficiency is not welcomed news

Pump Efficiency Measurements

Prerequisites for this Task:

- Essential Process Instruments
 - ◆ Flow Meter
 - ◆ Suction Pressure
 - ◆ Discharge Pressure
 - ◆ Power Meter
- Calculations – fairly simple math
 - ◆ kW required theoretical / actual

Math Required for Calculations

- Theoretical Horsepower

$$\text{HP} = \text{Flow (GPM)} * \text{TDH (feet)} / 3960$$

- Input Horsepower

$$\text{HP} = \text{Theoretical HP} /$$

(pump efficiency * motor efficiency)

- System Efficiency

$$\text{Eff \%} = \text{Theoretical} / \text{Actual HP} * 100$$

Instruments Used



Flow & Pressure



Power Measurement



SCADA Features Required

- On-line and Continuous Energy and Efficiency monitoring through use of higher technology electrical devices and software.
 - ◆ Networked connection for power measurement
 - ◆ Continuous measurement of pressures and flow
 - ◆ Local Processor for data acquisition and math

Energy Efficiency Software

- Designed for Siemens S7 series PLCs
- Simple to implement
- Data is available for local and master SCADA graphic panels

Continuous Power Measurement

- Profibus Networked Overloads
- Profibus Networked Power Meter
- Provides a complete picture of motor operation
- Data from this device fed directly in the energy efficiency software block.

Pressure and Flow Measurements

- Give careful review that the measured location of pressure may not be representative of the pressure at the pump intake or discharge.
- Fully investigate if the flowmeter measures all flow from the pump and if the location meets the manufacturer's requirements for accuracy.

On-Line Data at the Pump Station

°F 52.7
pH 8.15
0.3
CL2

W6 P

473.9
451.8
347.9

power
L-L
Amps
kW
HP-act
HP-theo
eff%

Pump Setup

Setpoints: HQ ▼

	Control	Ready	Status	
Well 6	Auto ▼	Ready	Run	95 % load
BP 1	Auto ▼	Ready	Run	74 % load
BP 2	Auto ▼	Off-line	Off	0 % load

Time Between Starts 15

OVERVIEW
WELL CMD
Setup
Control
Setpoints
WellSaver
CONTROL

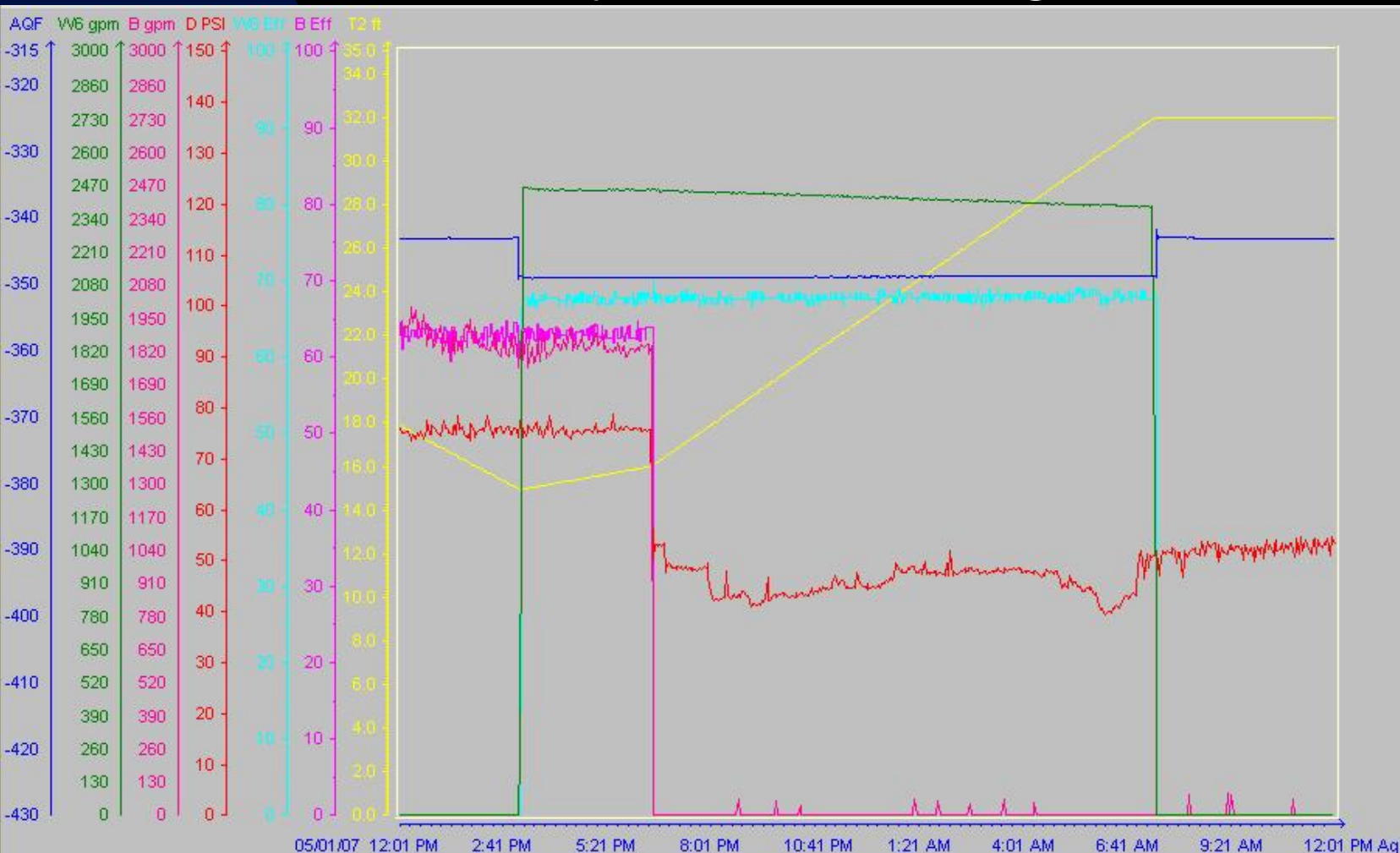
OVERVIEW

Overview

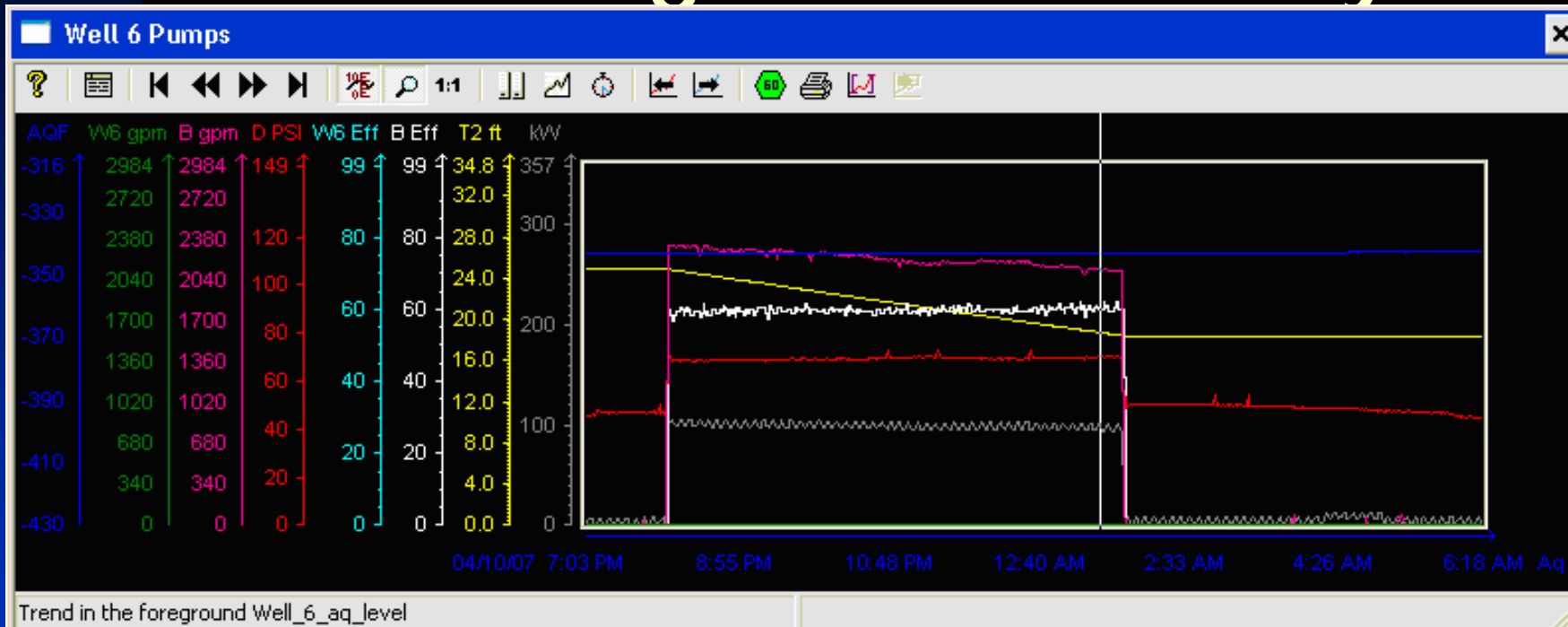
Menu

Examples of Efficiency in the Trends

A typical week long look at values



Total Dynamic Head and Changes to Efficiency



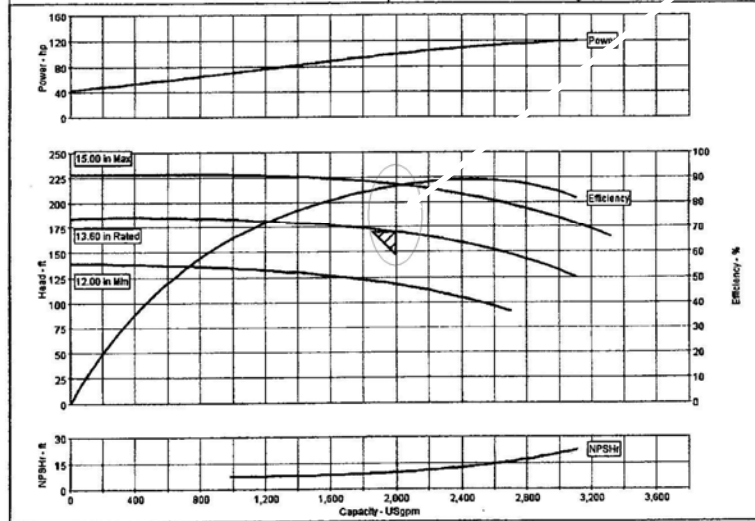
Well 6 Pumps

Trend	Value	Date/Time
Well_6_aq_level	-342.899994	04/11/07 1:30:42.265 AM
Well_6_Flow	-3.000000	04/11/07 1:30:42.265 AM
Well_6_Bst_Flow	2123.400000	04/11/07 1:30:42.265 AM
Discharge		04/11/07 1:30:42.265 AM
Well 6 Eff		04/11/07 1:30:38.624 AM
Booster Eff	59.90	04/11/07 1:31:02.265 AM
Tank_2_level	18.741000	04/11/07 1:30:42.265 AM
kW	100.66	04/11/07 1:31:42.265 AM

Typical efficiency for this Booster is 59 - 60%

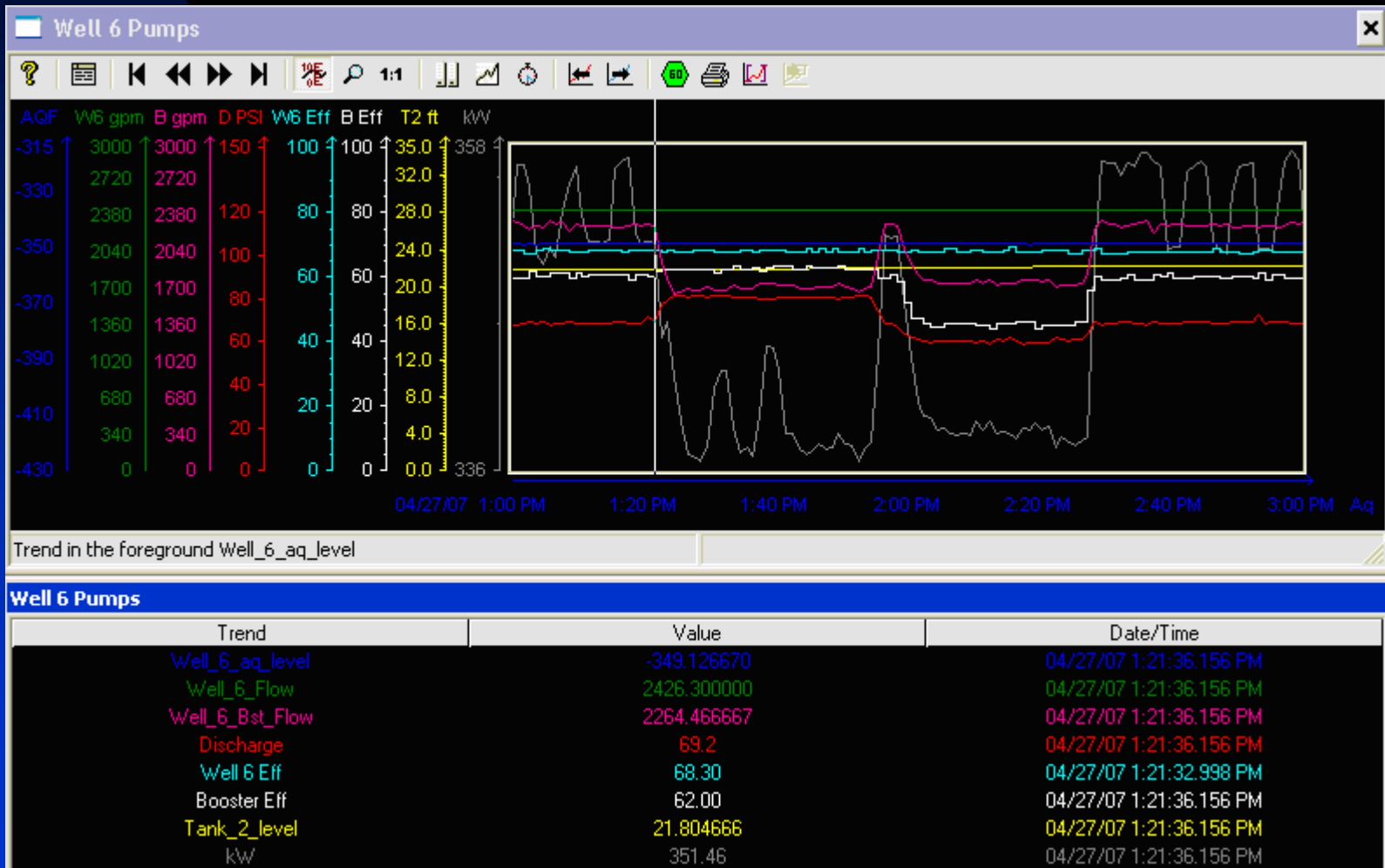
Pump Performance Datasheet			
Customer	:	Quote number	:
Customer reference	:	Pump size	: 60167 LF
Item number	:	Stages	: 1
Service	:	Based on curve number	: RC1935-1 Rev 0
Quantity of pumps	: 1	Date last saved	: 11 Sep 2006
Operating Conditions		Liquid	
Flow, rated	: 2,000 USgpm	Liquid type	: Water
Head, rated (requested)	: 170 ft	Additional liquid description	:
Head, rated (actual)	: 170 ft	Solids diameter, max	: 0.00 in
Suction pressure, rated / max	: 0.00 / 0.00 psi.g	Temperature, max	: 68.00 deg F
NPSH available, rated	: Ample	Fluid density, rated / max	: 0.998 / 0.998 SG
Frequency	: 60 Hz	Viscosity, rated	: 1.00 cP
Performance		Material	
Speed	: 1,750 rpm	Material requested	: Cast iron
Impeller diameter, rated	: 13.60 in	Material selected	: Cast iron
Impeller diameter, maximum	: 15.00 in		
Impeller diameter, minimum	: 12.00 in	Pressure Data	
Efficiency	: 86.42 %	Maximum working pressure	: 80.15 psi.g
NPSH required / margin required	: 9.63 / 0.00 ft	Maximum allowable working pressure	: 175.0 psi.g
Specific speed / Suction specific speed	: 1,726 / 11,565 US units	Maximum allowable suction pressure	: 175.0 psi.g
MCSF	: 760 USgpm	Hydrostatic test pressure	: 263.0 psi.g
Head, maximum, rated diameter	: 185 ft	Driver & Power Data	
Head rise to shutoff	: 8.38 %	Driver sizing specification	: Rated power
Flow, best eff. point (BEP)	: 2,469 USgpm	Margin over specification	: 0.00 %
Flow ratio (rated / BEP)	: 80.99 %	Service factor	: 1.00
Diameter ratio (rated / max)	: 90.67 %	Power, hydraulic	: 86 hp
Head ratio (rated dia / max dia)	: 73.09 %	Power, rated	: 99 hp
Viscous coefficients (CQ / CH / CE)	: 1.00 / 1.00 / 1.00	Power, maximum, rated diameter	: 120 hp
Selection status	: Acceptable	Minimum recommended driver rating	: 100 hp / 75 %

Where we expected this to operate.

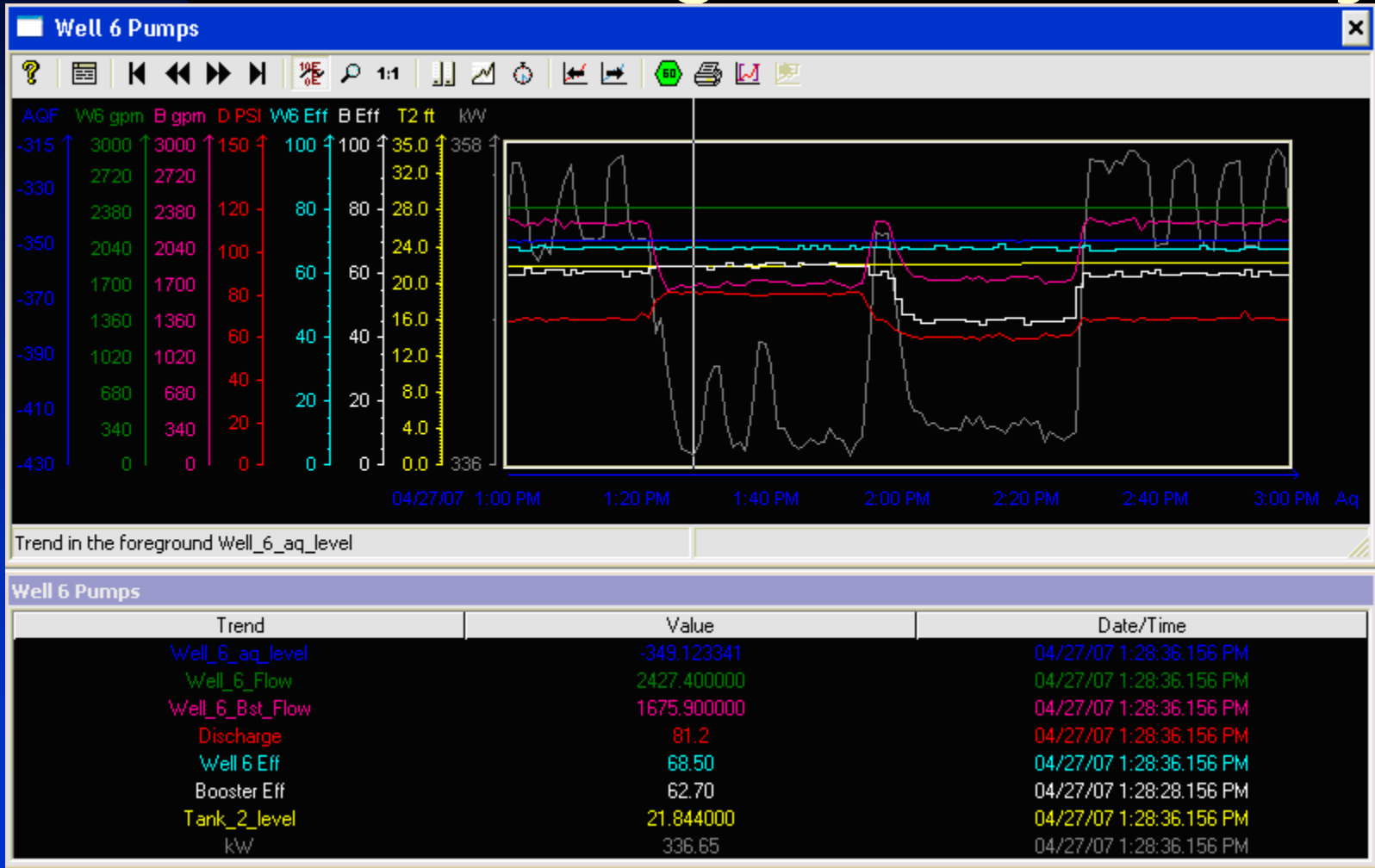


New Conditions.

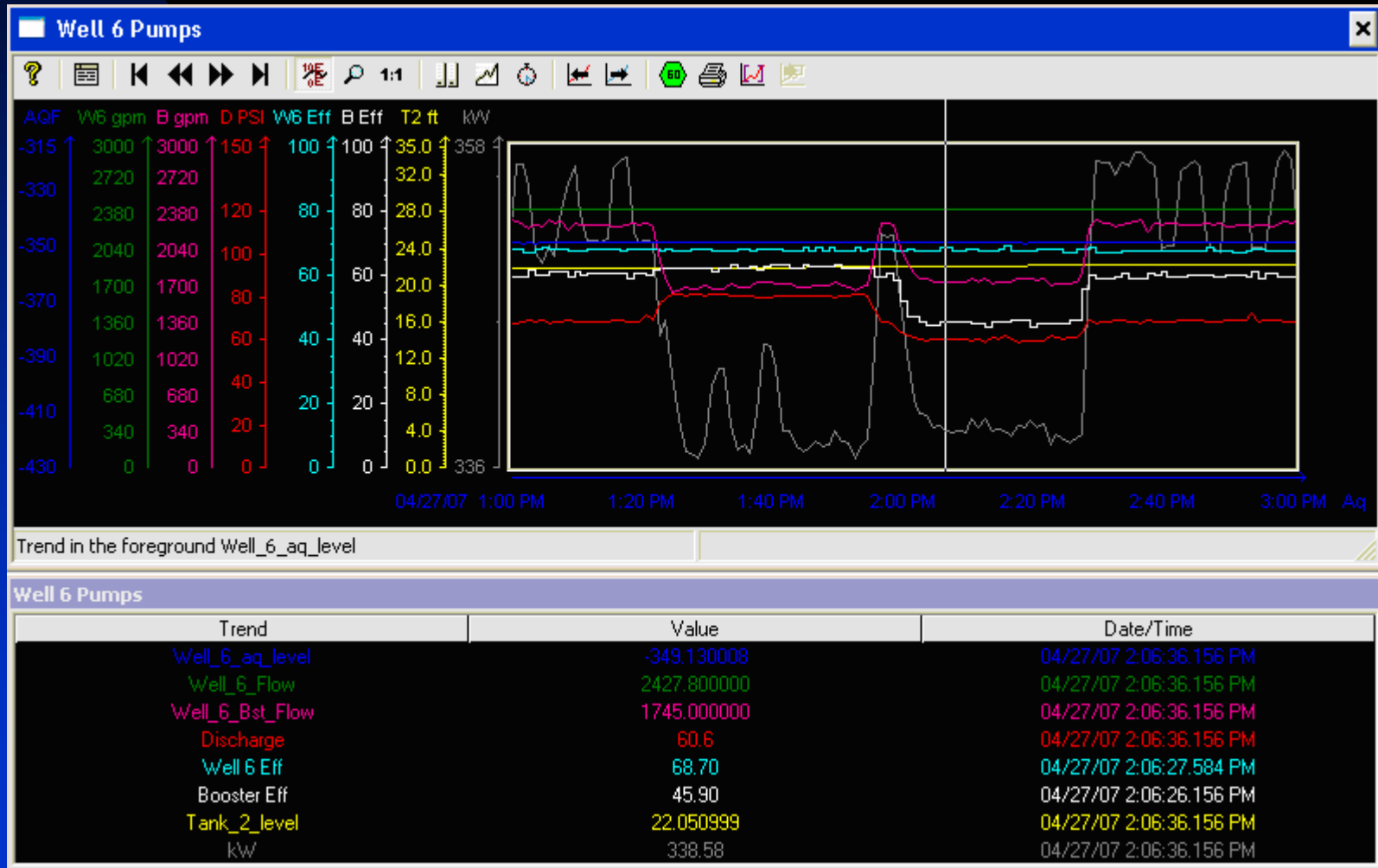
Total Dynamic Head and Changes to Efficiency



Total Dynamic Head and Changes to Efficiency



Total Dynamic Head and Changes to Efficiency



Software Requirements

The screenshot displays the SIMATIC Manager interface. The top window, titled "SIMATIC Manager - [Well6 -- C:\Projects\Redmond\Well6]", shows a project tree on the left and a table of objects in the center. The table lists:

Object name	Symbolic name	Size in...	Comment	Type
FB102	314C_Ain_fb	392	PLC Internal Analog Input Module S&B Inc. Software f...	Function Block
FB103	8ch_Ain_fb	726	PLC External 8 channel Analog Input Module S&B Inc...	Function Block

The bottom window, titled "LAD/STL/FBD - [FC133 -- 'PumpEff' -- Well6\314C2DP\CPU 314C-2 DP\...FC133]", shows a ladder logic network diagram. The diagram includes a function block call for "WellEff" with the following connections:

- Network 7: Well Pump Efficiency. Comment: [Redacted].
- Inputs: #0.1, #tmp_real2 - Discharge, "AI_314C". AIn_1, P0_Real - Suction, "AI_314C". AIn_2, P0_Real - GPM, ..., HP, "off" - Disch2Ft, "off" - Suct2Ft.
- Outputs: EMO, "Datapass" - RTU_051, Eff.

The interface also features a menu bar (File, Edit, Insert, PLC, Debug, View, Options, Window, Help), a toolbar, and a status bar at the bottom with the text "Press F1 to get Help." and "offline Abs < 5.2 Insert".

The "Required List" for on-line efficiency monitoring?

- A SCADA system
- High Technology Motor Monitors
- RTU/PLCs capable of basic math
- Software

What is the cost to monitor cost?

- \$15 - \$16k New RTU/PLC complete
- < \$1k Per Motor for monitors
- < \$1k Per pressure transmitter
- ~ \$4k 12" Mag Flowmeter

Incremental cost on a new application

- < \$400 Software and Docs