Better Plants®
U.S. DEPARTMENT OF ENERGY

Pumping System Assessment

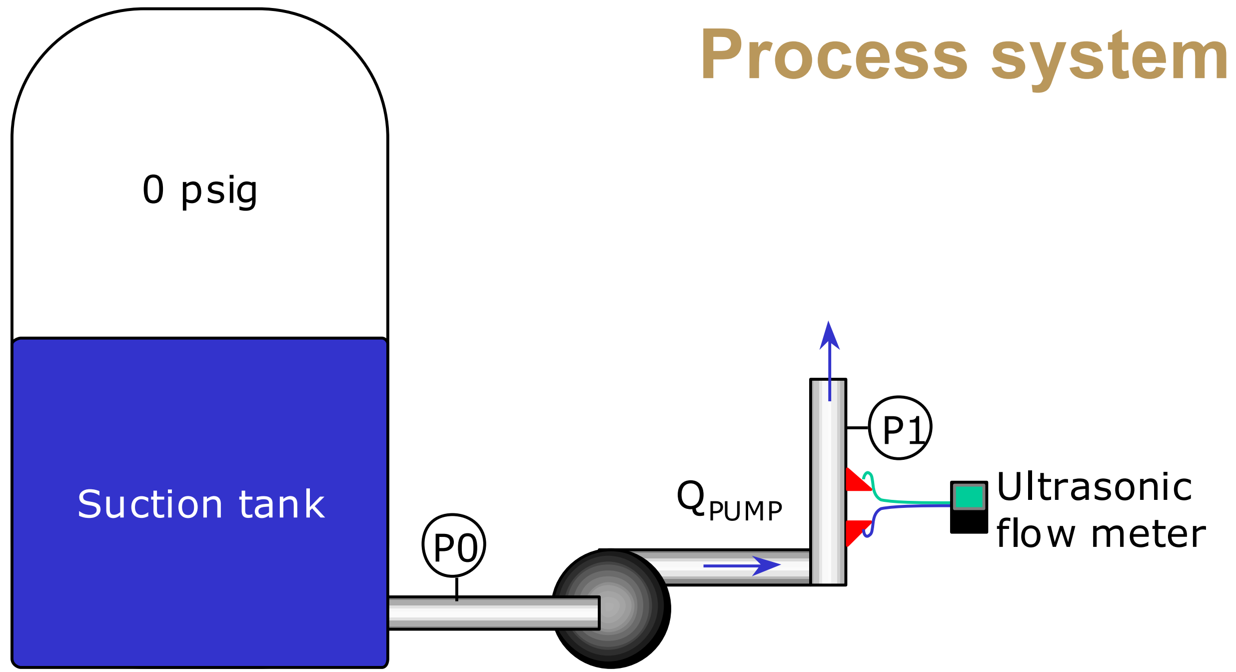
Week 4: Finding Data and Examples

U.S. DEPARTMENT OF ENERGY

Example System for Field Investigation and Analysis

A Flow Control System

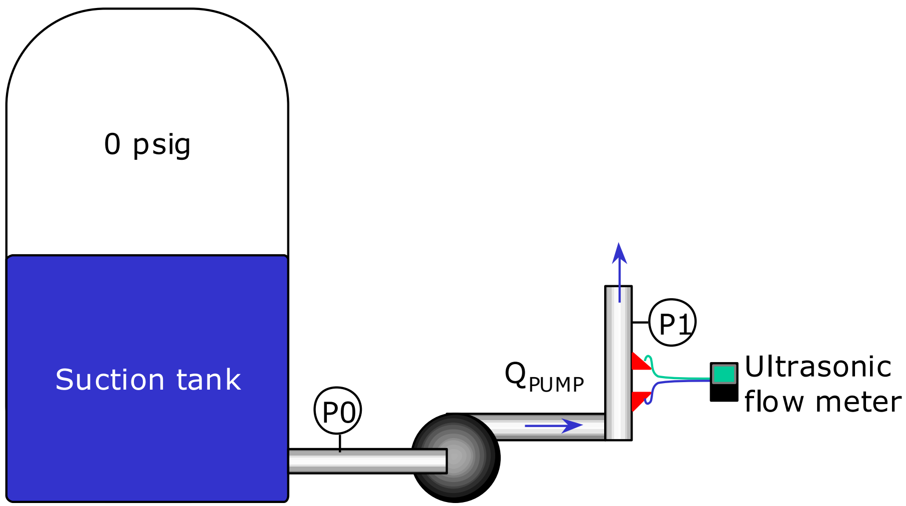
Some systems operate continuously but need to have their flow regulated. The flow requirements are dictated by the process, and one would not attempt to maximize the pump efficiency by valve operation. However, operating pump efficiency could be deduced using system measurements. An example process pumping system with a flow control valve is shown below.



Measured data at the pump

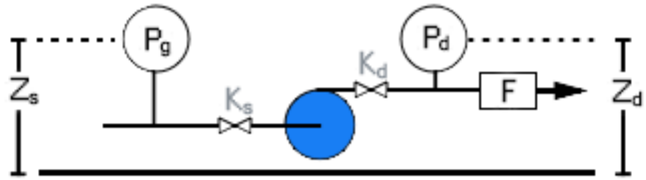
Measured Conditions

Water at ambient temperature
P0: 4.3 psig, 7 ft. above floor level; pipe ID = 19.5 inches
P1: 81.2 psig, 12.4 ft above floor level; pipe ID = 12.25 inches
Measured flow rate, using temporary ultrasonic flow meter: 6100 gpm
Motor nameplate data: 2300 volts, 1180 rpm, 80 amps (rated load), 350 hp
Measured current and voltage: 77 amps, 2320 volts
Pump style: End suction
Observed rotational speed: 1190 rpm
Pump operates about 90% of the time; electricity cost is 13 cents/kWhr



Calculate pump head

Suction tank elevation | **Suction gauge elevation**



K_s represents all suction losses from the tank to the pump

K_d represents all discharge losses from the pump to the gauge P_d

Fluid Specific Gravity	1
Flow Rate	6100 gpm

Suction		Discharge	
Pipe diameter (ID)	19.5 in	Pipe diameter (ID)	12.25 in
Gauge pressure (P_g)	4.3 psi	Gauge pressure (P_d)	81.2 psi
Gauge elevation (Z_s)	7 ft	Gauge elevation (Z_d)	12.4 ft
Line loss coefficients (K_s)	0.5	Line loss coefficients (K_d)	1.5

Result Data

Differential Elevation Head	5.4 ft
Differential Pressure Head	177.7 ft
Differential Velocity Head	3.62 ft
Estimated Suction Friction Head	0.33 ft
Discharge Friction Head	6.43 ft
Pump Head	193.48 ft

Pump head calculation from MEASUR

Evaluate pump operating efficiency

As a first check of the pump operation, the hydraulic and electrical data were plugged into the MEASUR software. The results, shown below, indicate that the pump is very near the optimum commercially available equipment for the noted conditions. MEASUR estimates the pump efficiency to be 87.6%.

Evaluate pump operating efficiency

BASELINE

Operating Hours	7884	hrs/yr
Electricity Cost	0.13	$/kWh
Flow Rate	6100	gpm
Head Calculate Head	193	ft
Load Estimation Method	Current	
Motor Current	77	A
Measured Voltage	2320	V

OPTIMAL PUMP

Operating Hours	7884	hrs/yr
Electricity Cost	0.13	$/kWh
Flow Rate	6100	gpm
Head Calculate Head	193	ft
Implementation Costs		$

Evaluate pump operating efficiency

BASELINE

Pump Type	API Double Suction
Pump Speed	1190 rpm
Drive	Direct Drive
Fluid Type	Water
Fluid Temperature	68 °F
Specific Gravity	1
Kinematic Viscosity	1 cSt
Stages	− + 1
Line Frequency	60 Hz
Rated Motor Power	350 hp
Motor RPM	1180 rpm
Efficiency Class	Energy Efficient
Rated Voltage	2300 V
Full-Load Amps	80 A

OPTIMAL PUMP

Pump Efficiency: 89.9 %

Optimize Pump

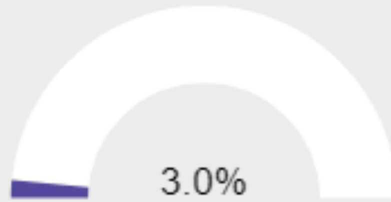
The efficiency of your pump has been calculated based on your system setup. Either directly modify your efficiency or click **"Optimize Pump"** to estimate your pump efficiency based on a different pump type.

Pump Speed	1190 rpm
Drive	Specified Efficiency
Drive Efficiency	100 %
Fluid Type	Water
Fluid Temperature	68 °F
Specific Gravity	1
Kinematic Viscosity	1 cSt
Stages	− + 1
Line Frequency	60 Hz
Rated Motor Power	350 hp
Motor RPM	1180 rpm
Efficiency Class	Energy Efficient
Rated Voltage	2300 V
Full-Load Amps	80 A

Estimate Full-Load Amps

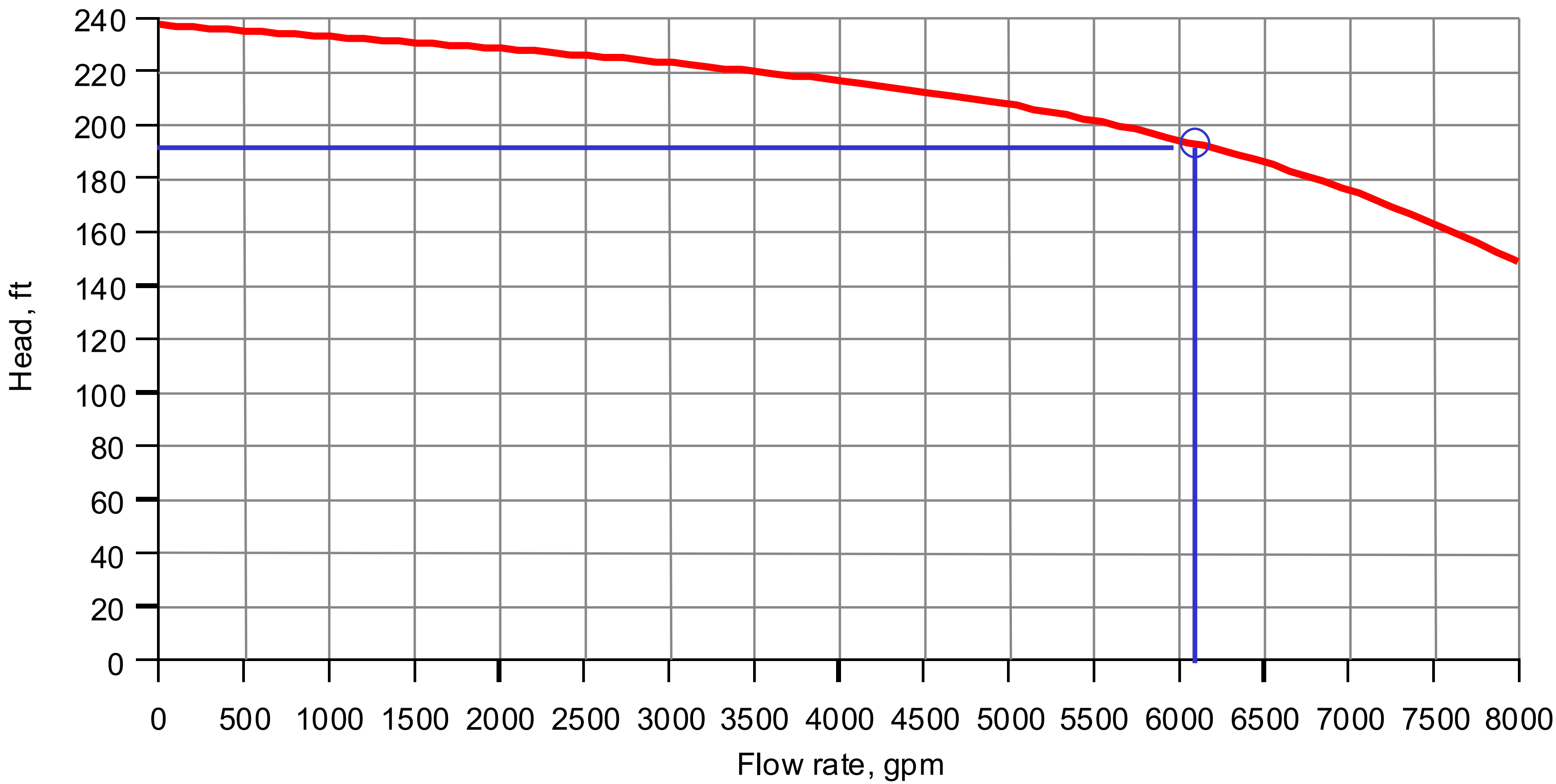
Evaluate pump operating efficiency

RESULTS | SANKEY | HELP

	Baseline	Optimal Pump
Percent Savings (%)	— —	 3.0%
Pump efficiency (%)	87.6	89.9
Motor rated power (hp)	350	350
Motor shaft power (hp)	339.2	330.6
Pump shaft power (hp)	339.2	330.6
Motor efficiency (%)	95.6	95.6
Motor power factor (%)	85.6	84.2
Percent Loaded (%)	97	94
Drive efficiency (%)	100	100
Motor current (amps)	77	76
Motor power (kW)	264.7	258
Annual Energy (MWh)	**2,087**	**2,034**
Annual Energy Savings (MWh)	**—**	**53**
Annual Cost	**$271,327**	**$264,429**
Annual Savings	**—**	**$6,899**

Check the manufacturer’s data

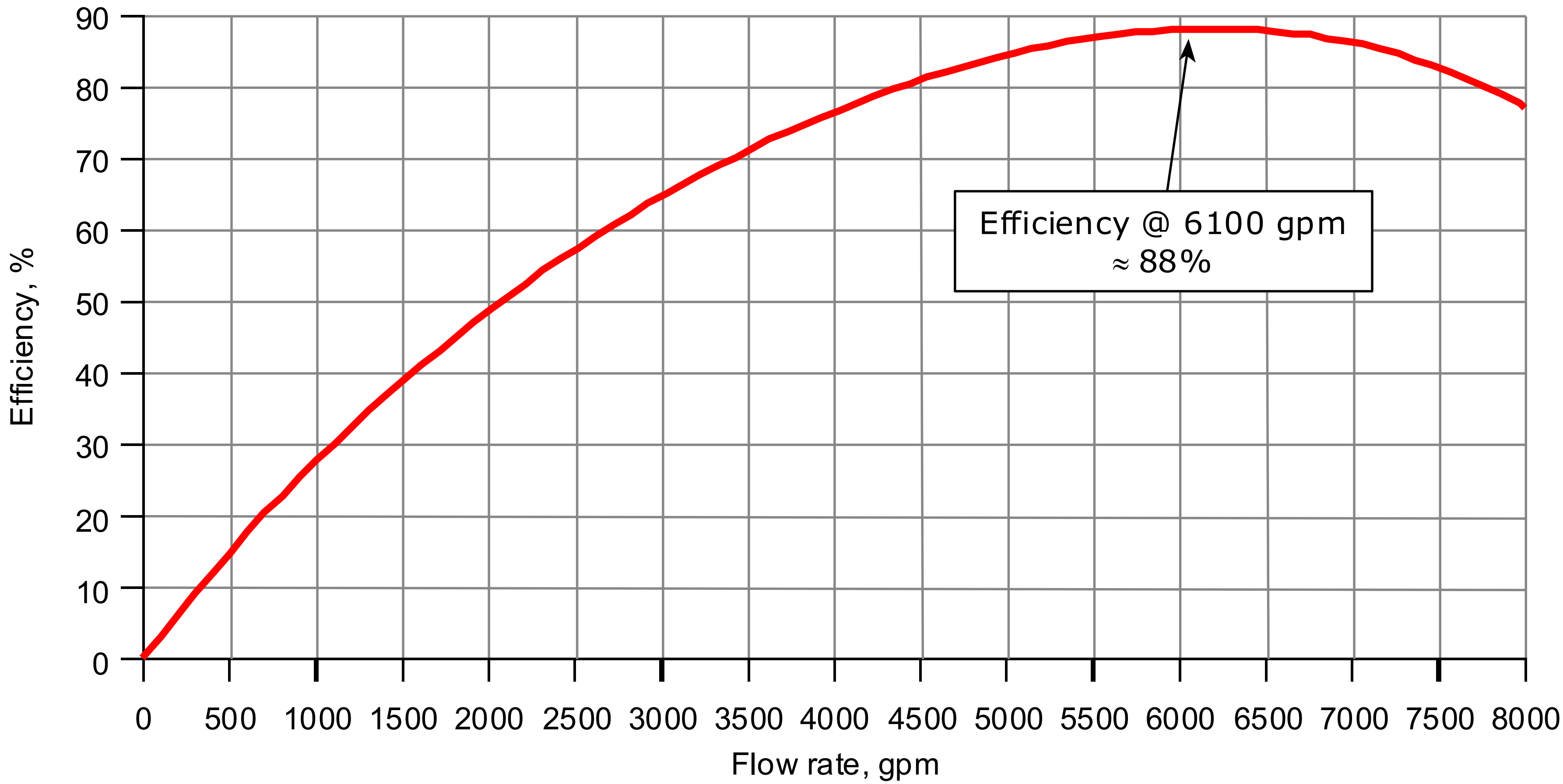
To provide an independent check on the measured data, the manufacturer’s pump performance curves, adjusted for the observed speed (using the pump affinity laws) were consulted. The head-capacity curve is shown below.



Pump head-capacity curve

Check the manufacturer's data

The efficiency-capacity curve is shown below.



Pump efficiency-capacity curve

A happy pump!

The calculated head and flow rate match the manufacturer's curve; furthermore, the MEASUR-estimated efficiency is consistent with the manufacturer's curve.

In summary, the observed measurements and subsequent analysis suggests that the pump:

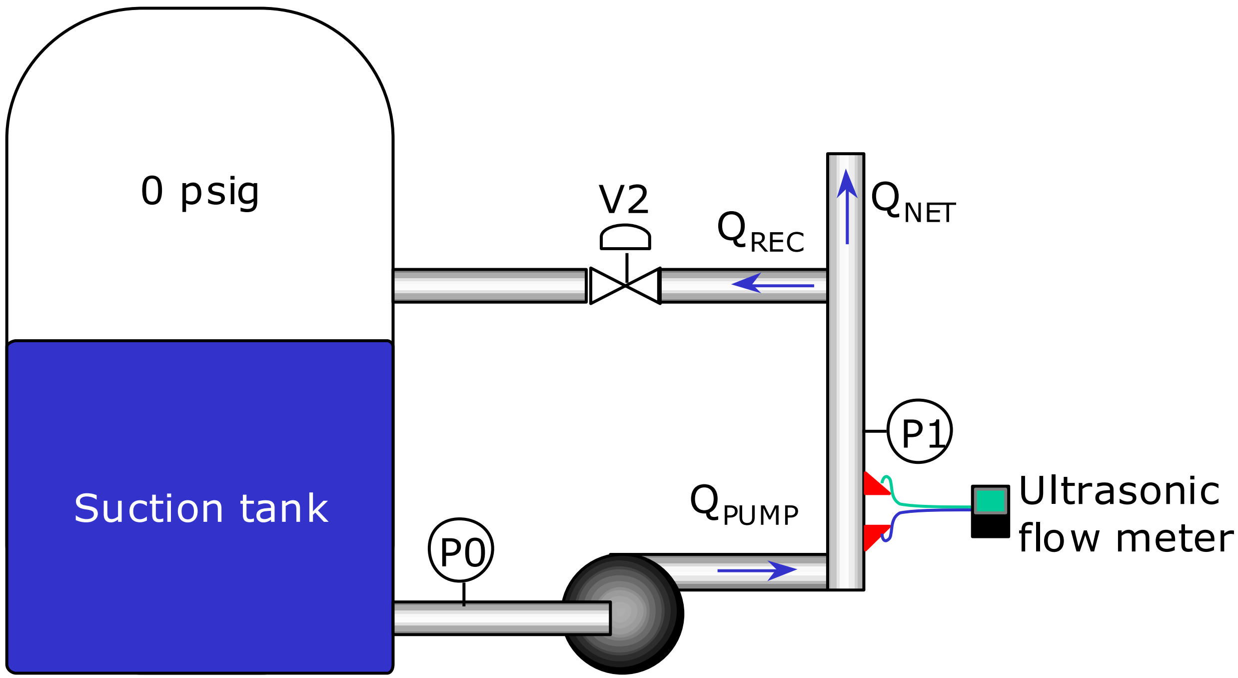
- is operating very near its BEP (best efficiency point)
- is operating consistent with the manufacturer's performance curves, indicating minimal wear along with the motor, is operating near the PSAT-calculated optimal condition (note that the Optimization Rating is 97.4.

The Optimization Rating is a measure of the combined motor and pump performance relative to the optimal commercially available equipment, expressed as a percentage (equivalent to a grade on an exam).

As will be shown, these observations, while true, are very misleading. They apply to the motor and pump *only*.

Moving downstream a little we find…..

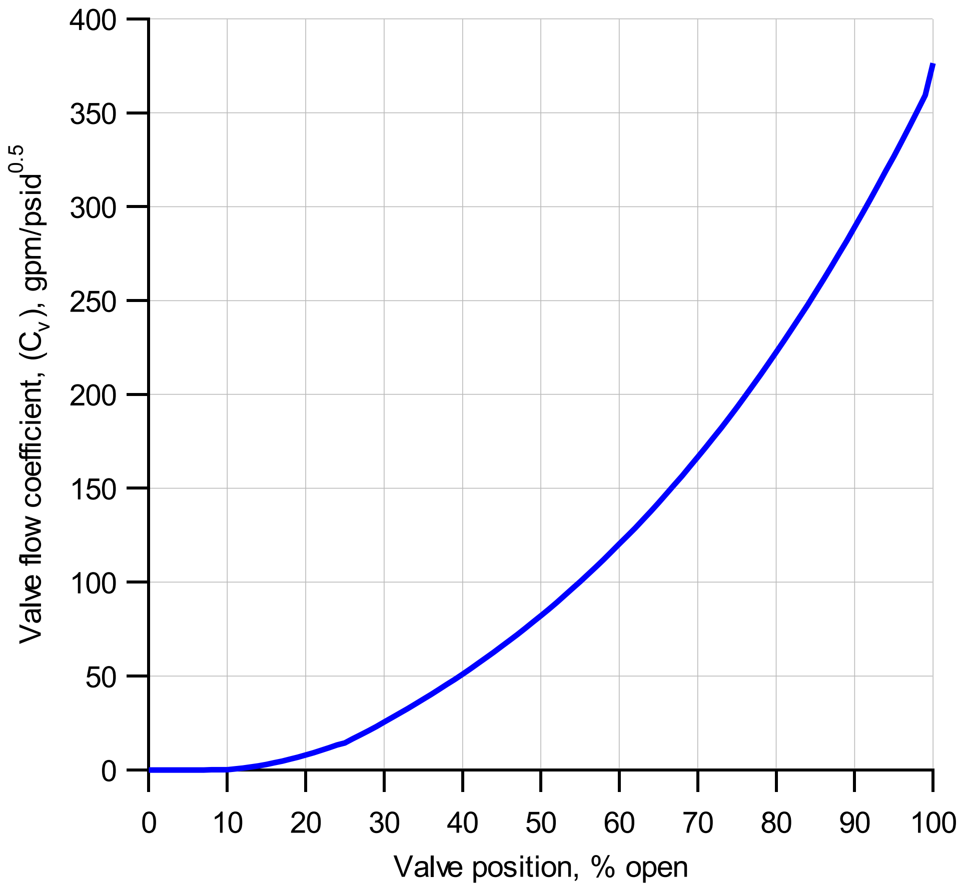
As noted above, the pump and motor are operating very efficiently, as judged by the head and flow rate output compared with the electrical power input. But it should always be the goal to judge how well the system as a whole is functioning, not just the individual components. Below, a slightly broadened view of the system is shown. A portion of the flow handled by the pump is diverted and recirculated back to the suction tank. This recirculated flow represents wasted energy.



Process system, including recirculation line

The recirculation line control valve

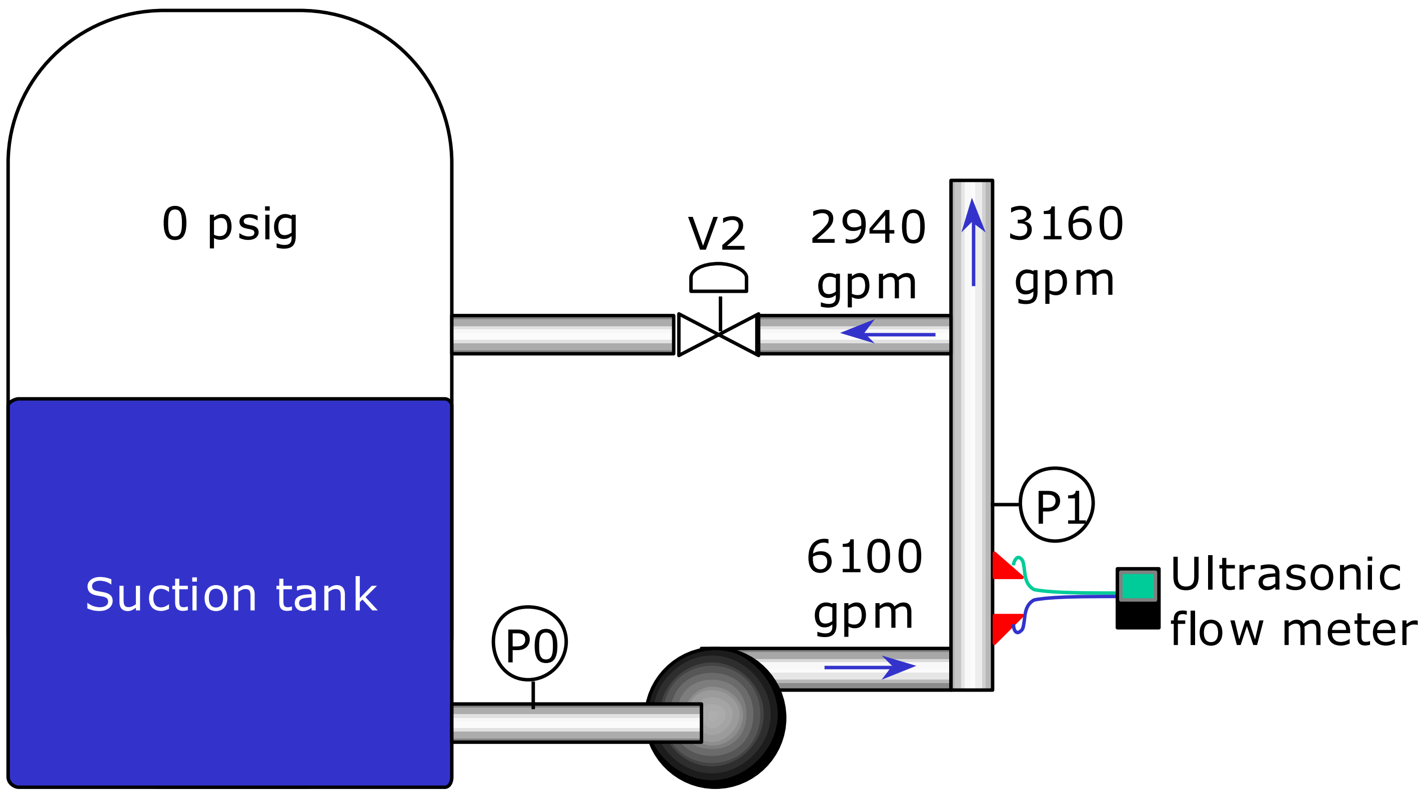
Flow rate was not measured in the recirculation line, but valve V2 position was noted to be full open. A picture of a valve similar to the recirculation valve, and valve flow coefficient vs. position are shown below.



Control valve (similar design to recirculation valve) and flow coefficient vs. position

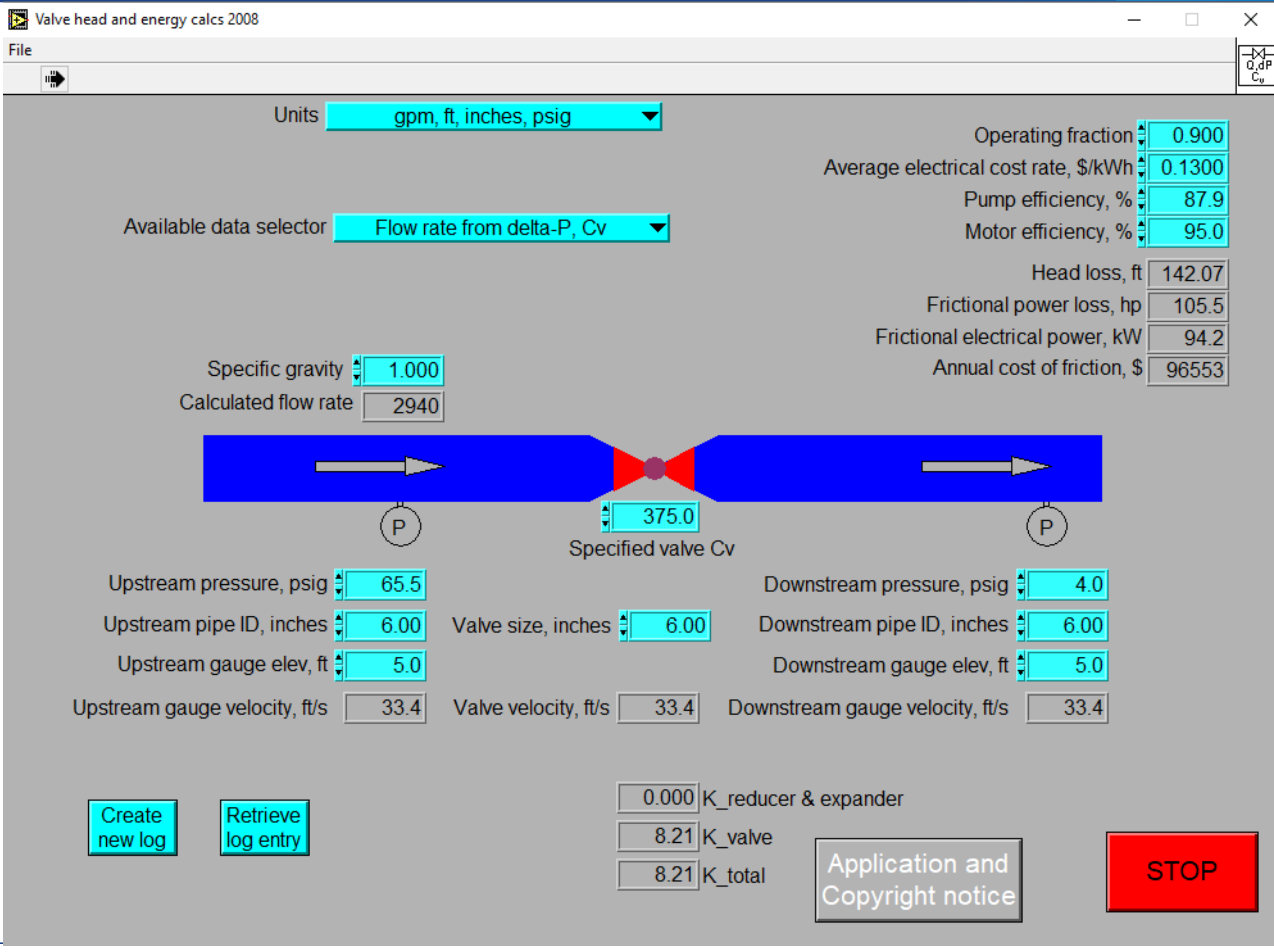
Pumping 2940 gpm around in a circle!

Using the valve performance data, pipe and component geometric data, and measured pressures, the flow rate through the recirculation line was estimated to be 2940 gpm. Thus, the net flow rate is 3160 gpm. The flow distributions are illustrated below.



Process system flow distribution

Could use Valve Tool to estimate flow



Gaining A System Perspective

Recognizing that only a little more than half the pump flow rate (3160 gpm) is going to the intended target, a revised MEASUR analysis can be performed using this net flow value. The result is shown below.

MEASUR analysis continued,

BASELINE

Operating Hours	7884	hrs/yr
Electricity Cost	0.13	$/kWh
Flow Rate	6100	gpm
Head Calculate Head	193	ft
Load Estimation Method	Current	
Motor Current	77	A
Measured Voltage	2320	V

USEFUL FLOW IS 3160 GPM

Operating Hours	7884	hrs/yr
Electricity Cost	0.13	$/kWh
Flow Rate	3160	gpm
Head Calculate Head	193	ft
Implementation Costs		$

MEASUR analysis

BASELINE

Pump Type	API Double Suction
Pump Speed	1190 rpm
Drive	Direct Drive
Fluid Type	Water
Fluid Temperature	68 ℉
Specific Gravity	1
Kinematic Viscosity	1 cSt
Stages	− + 1
Line Frequency	60 Hz
Rated Motor Power	350 hp
Motor RPM	1180 rpm
Efficiency Class	Energy Efficient
Rated Voltage	2300 V
Full-Load Amps	80 A

USEFUL FLOW IS 3160 GPM

Pump Efficiency: 45.3906 %

Optimize Pump

The efficiency of your pump has been calculated based on your system setup. Either directly modify your efficiency or click **"Optimize Pump"** to estimate your pump efficiency based on a different pump type.

Pump Speed	1190 rpm
Drive	Specified Efficiency
Drive Efficiency	100 %
Fluid Type	Water
Fluid Temperature	68 ℉
Specific Gravity	1
Kinematic Viscosity	1 cSt
Stages	− + 1
Line Frequency	60 Hz
Rated Motor Power	350 hp
Motor RPM	1180 rpm
Efficiency Class	Energy Efficient
Rated Voltage	2300 V
Full-Load Amps	80 A

Estimate Full-Load Amps

Gaining A System Perspective

RESULTS	SANKEY	HELP

	Baseline	Useful Flow is 3160 gpm
Percent Savings (%)	— —	
Pump efficiency (%)	87.6	45.4
Motor rated power (hp)	350	350
Motor shaft power (hp)	339.2	339.2
Pump shaft power (hp)	339.2	339.2
Motor efficiency (%)	95.6	95.6
Motor power factor (%)	85.6	84.4
Percent Loaded (%)	97	97
Drive efficiency (%)	100	100
Motor current (amps)	77	78
Motor power (kW)	264.7	264.7
Annual Energy (MWh)	**2,087**	**2,087**
Annual Energy Savings (MWh)	**—**	
Annual Cost	**$271,327**	**$271,327**
Annual Savings	**—**	**$00**

Optimum pump is 88.5% efficient

RESULTS | SANKEY | HELP

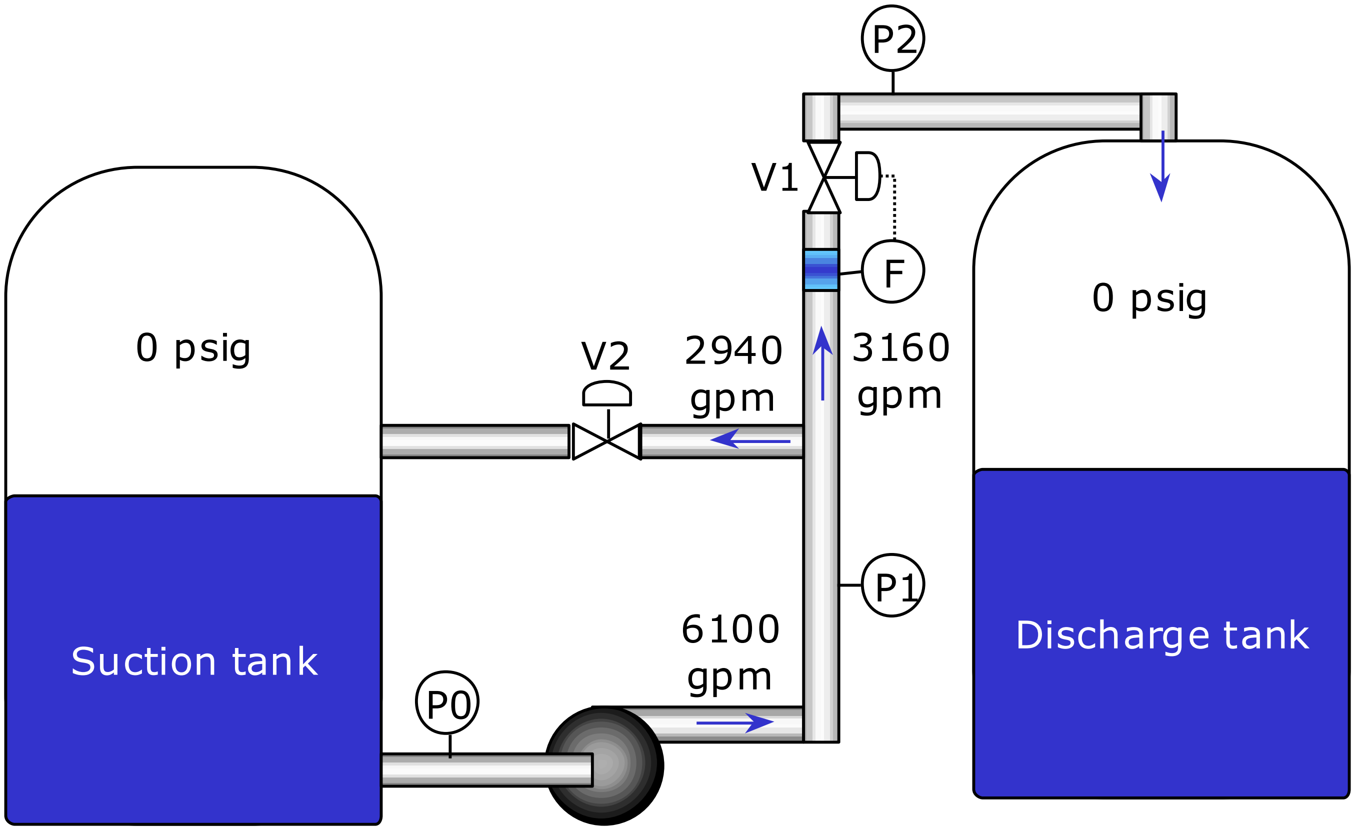
	Baseline	Optimized Pump at 3160 gpm
Percent Savings (%)	— —	48.0%
Pump efficiency (%)	87.6	88.5
Motor rated power (hp)	350	350
Motor shaft power (hp)	339.2	174
Pump shaft power (hp)	339.2	174
Motor efficiency (%)	95.6	94.7
Motor power factor (%)	85.6	74.9
Percent Loaded (%)	97	50
Drive efficiency (%)	100	100
Motor current (amps)	77	45
Motor power (kW)	264.7	137
Annual Energy (MWh)	**2,087**	**1,080**
Annual Energy Savings (MWh)	**—**	**1,007**
Annual Cost	**$271,327**	**$140,397**
Annual Savings	**—**	**$130,930**

Gaining A System Perspective

There is a dramatic effect on the outcome; the Optimization Rating dropped from 97.4 to 51.3. Significantly, the annual cost, estimated to be $271,300, could be reduced by $131,000 with a pump selected to deliver the net flow only (i.e., with the bypass or recirculation valve closed).

Going further downstream…..

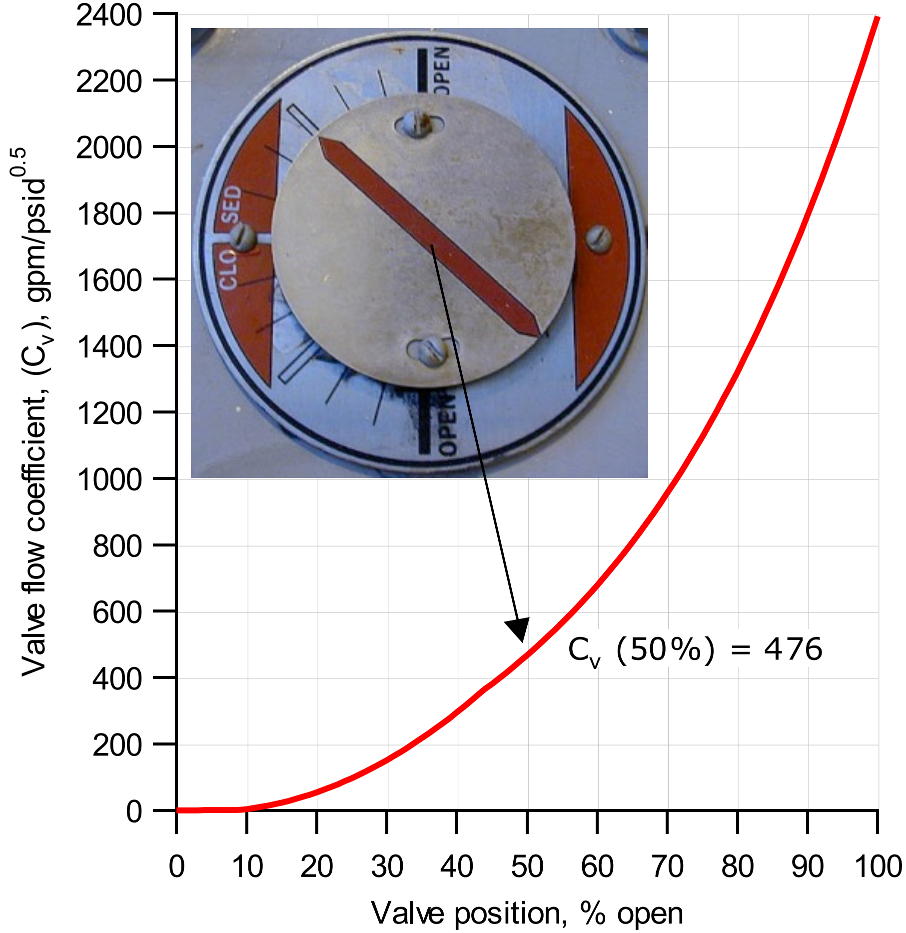
Expanding the view to include the entire system shows that the flow rate to the receiver, or discharge tank, is controlled by another valve, V1, whose position is controlled by a signal from an in-line magnetic flow meter.



Complete process system diagram

There is this pinched flow control valve

A picture of the flow meter and control valve is provided below.



Magnetic flow meter and control valve (valve labeled V1), close-up of valve position, and valve flow coefficient vs. position plot

Using the valve equation

Based on the calculated valve flow coefficient of 476 from the valve indicator and valve flow coefficient plot, the pressure drop across the control valve can be estimated. The fundamental equation relating the valve flow coefficient, flow rate, and pressure drop is:

$$Q = C_v \sqrt{\frac{\Delta P}{s.g.}} \quad \text{or} \quad \Delta P = \frac{s.g.\ x\ Q^2}{C_v^2} \quad \rightarrow \quad \Delta P = \frac{1.0\ x\ 3160^2}{476^2} = 44\ \text{psig}$$

where Q is the flow rate in gpm, Cv is the valve flow coefficient, DP is the pressure drop across the valve in psig, and s.g. is the specific gravity. The pressure drop across the valve was actually measured to be 39 psig.

Gaining A System Perspective

The pressure drop across the valve represents head developed by the pump that exceeds that necessary to deliver the required flow rate to the discharge tank. This pressure drop can be subtracted from the pump head to calculate the head actually required. The MEASUR analysis was re-run after subtracting the measured head loss (39 psig * 2.31 ft/psig = 90 ft) from the calculated pump head (193.5 ft) previously used.

Downsize pump and motor

BASELINE

Operating Hours	7884 hrs/yr
Electricity Cost	0.13 $/kWh
Flow Rate	6100 gpm
Head Calculate Head	193 ft
Load Estimation Method	Current
Motor Current	77 A
Measured Voltage	2320 V

OPTIMIZED PUMP AT 3160 GPM @ 103 FT

Operating Hours	7884 hrs/yr
Electricity Cost	0.13 $/kWh
Flow Rate	3160 gpm
Head Calculate Head	103 ft
Implementation Costs	$

Downsize pump and motor

BASELINE

Pump Type	API Double Suction
Pump Speed	1190 rpm
Drive	Direct Drive
Fluid Type	Water
Fluid Temperature	68 °F
Specific Gravity	1
Kinematic Viscosity	1 cSt
Stages	− + 1
Line Frequency	60 Hz
Rated Motor Power	350 hp
Motor RPM	1180 rpm
Efficiency Class	Energy Efficient
Rated Voltage	2300 V
Full-Load Amps	80 A

OPTIMIZED PUMP AT 3160 GPM @ 103 FT

Pump Efficiency Optimize Pump	88.5 %

The efficiency of your pump has been calculated based on your system setup. Either directly modify your efficiency or click **"Optimize Pump"** to estimate your pump efficiency based on a different pump type.

Pump Speed	1190 rpm
Drive	Specified Efficiency
Drive Efficiency	100 %
Fluid Type	Water
Fluid Temperature	68 °F
Specific Gravity	1
Kinematic Viscosity	1 cSt
Stages	− + 1
Line Frequency	60 Hz
Rated Motor Power	100 hp
Motor RPM	1180 rpm
Efficiency Class	Energy Efficient
Rated Voltage	2300 V
Full-Load Amps Estimate Full-Load Amps	23.79 A

Downsize pump and motor

RESULTS | SANKEY | HELP

	Baseline	Optimized Pump at 3160 gpm @ 103 ft
Percent Savings (%)	— —	72.0%
Pump efficiency (%)	87.6	88.5
Motor rated power (hp)	350	100
Motor shaft power (hp)	339.2	92.8
Pump shaft power (hp)	339.2	92.8
Motor efficiency (%)	95.6	94.8
Motor power factor (%)	85.6	82.7
Percent Loaded (%)	97	93
Drive efficiency (%)	100	100
Motor current (amps)	77	22
Motor power (kW)	264.7	73.1
Annual Energy (MWh)	**2,087**	**576**
Annual Energy Savings (MWh)	**—**	**1,511**
Annual Cost	**$271,327**	**$74,888**
Annual Savings	**—**	**$196,439**

Gaining A System Perspective

Thus, when viewed from a component perspective, the pump and motor operate very efficiently; however, when viewed from a system perspective, the pump is significantly oversized for the job at hand. Note that in the MEASUR analysis, the optimal pump could be powered by a 100 hp motor instead of the 350 hp motor required for the existing pump. Also note that the annual energy cost could be reduced by almost $200,000 if the optimal pump and motor were employed.

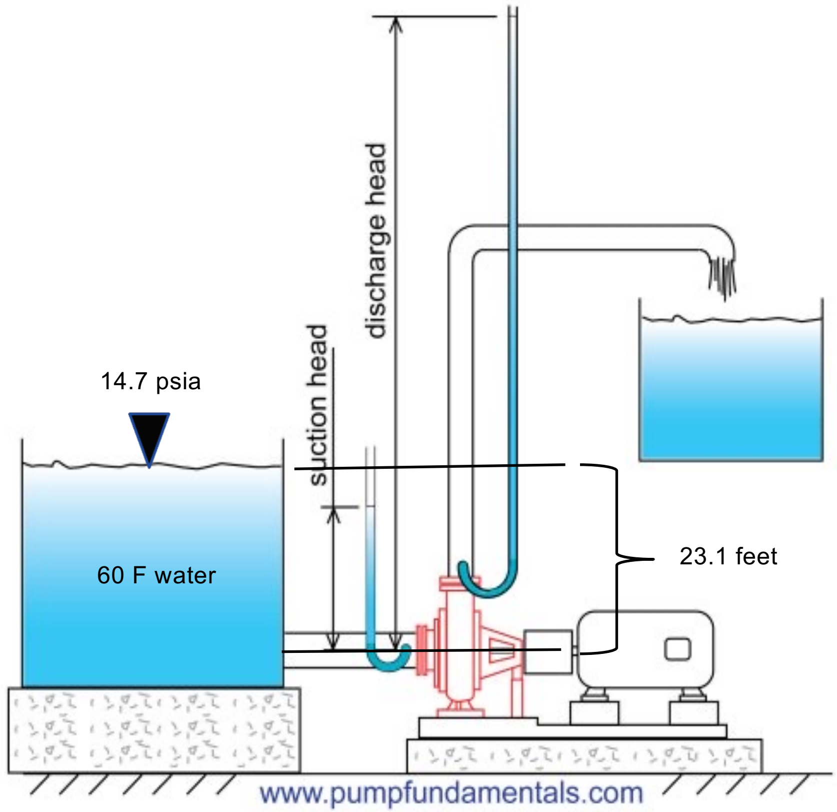
Concluding Remarks

This article has demonstrated two important perspectives related to valve control of pumping systems:

Throttling valves to achieve improved pump efficiency in systems whose function is to deliver a given volume is almost never a good idea,

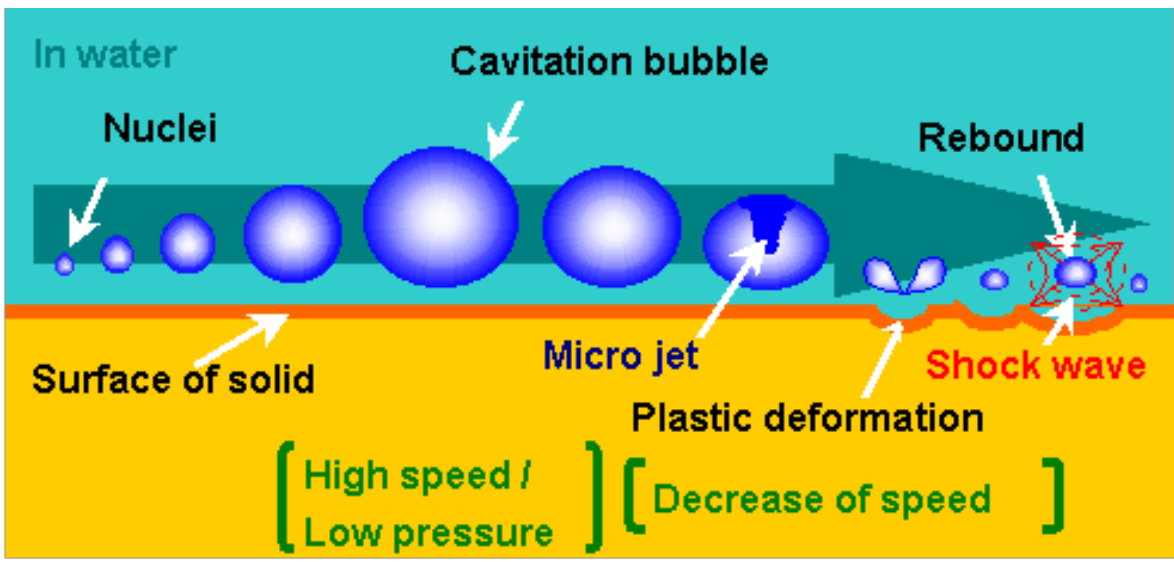
Efficient pump and/or motor operation is decidedly not an indication of effective or efficient system operation.

Cavitation



Water Boils at:

- 212 F when the pressure is 14.70 psia
- 203 F when the pressure is 12.27 psia
- 60 F when the pressure is 0.26 psia
- 250 F when the pressure is 28.84 psia



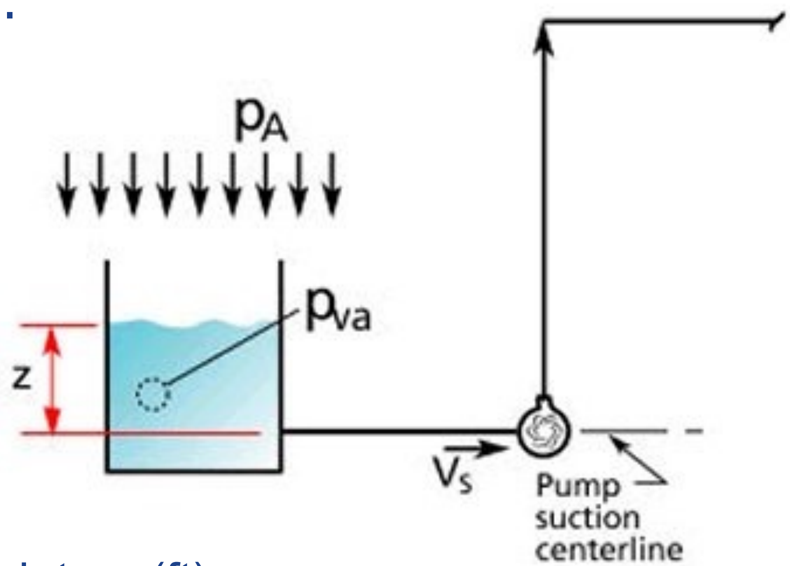
Net Positive Suction Head

Net Positive Suction Head

$$NPSHA = Total\ suction\ head\ (absolute) - fluid\ vapor\ pressure\ (absolute)$$

$$NPSHA = \frac{{V_s}^2}{2g} + \frac{2.31(P_s + P_a)}{s.g.} + Z_s - \frac{2.31 P_v}{s.g.}$$

$$NPSHA = \frac{{V_s}^2}{2g} + \frac{2.31(P_s + P_a - P_v)}{s.g.} + Z_s$$

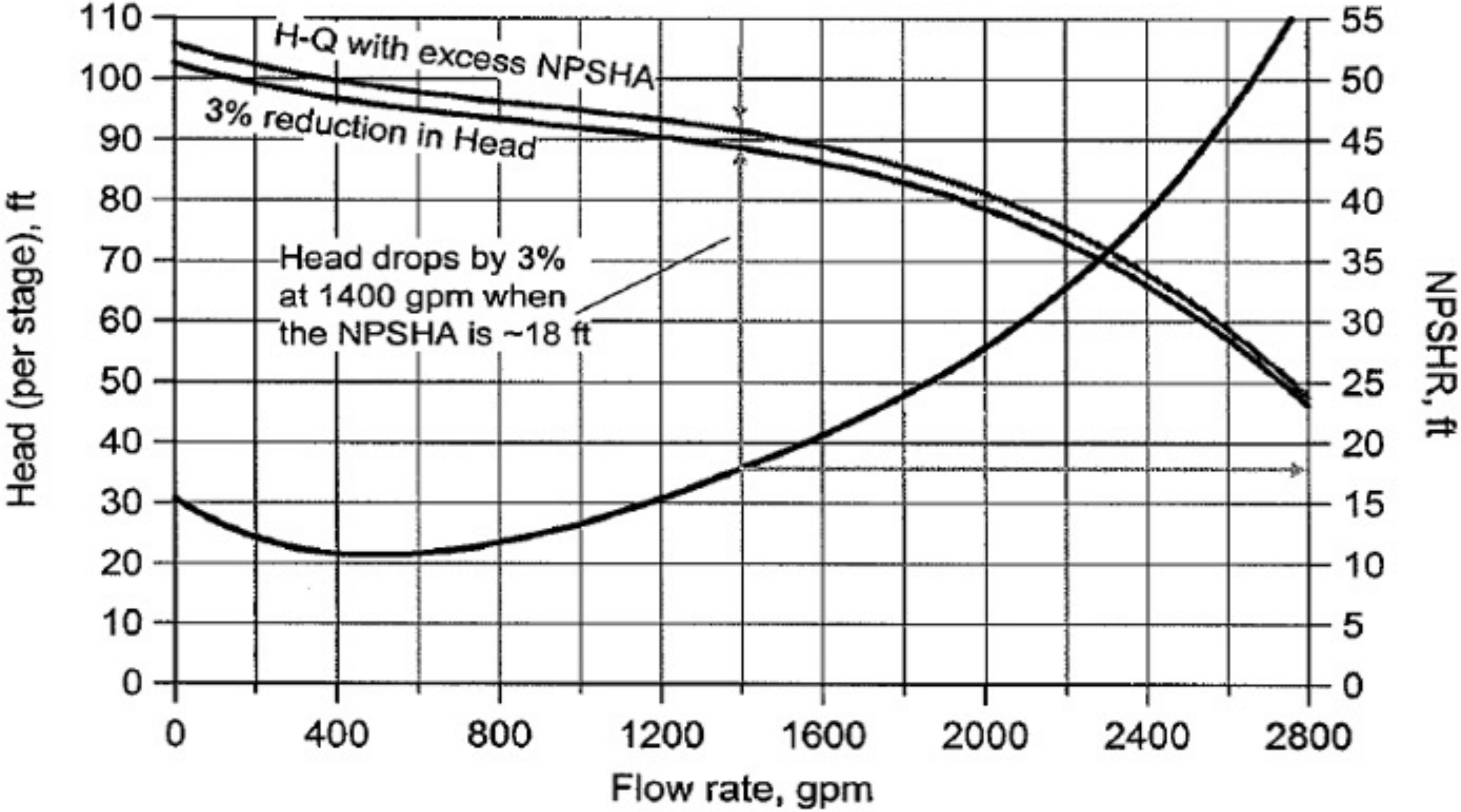


V_s = pump suction velocity (ft/s)
P_s = suction gauge pressure (psig)
P_a = atmospheric pressure (psia)
P_v = fluid vapor pressure (psia)
g = gravitational constant (32.174 ft/s^2)
s.g. = fluid specific gravity (dimensionless)
Z_s = suction gauge elevation above pump suction datum (ft)

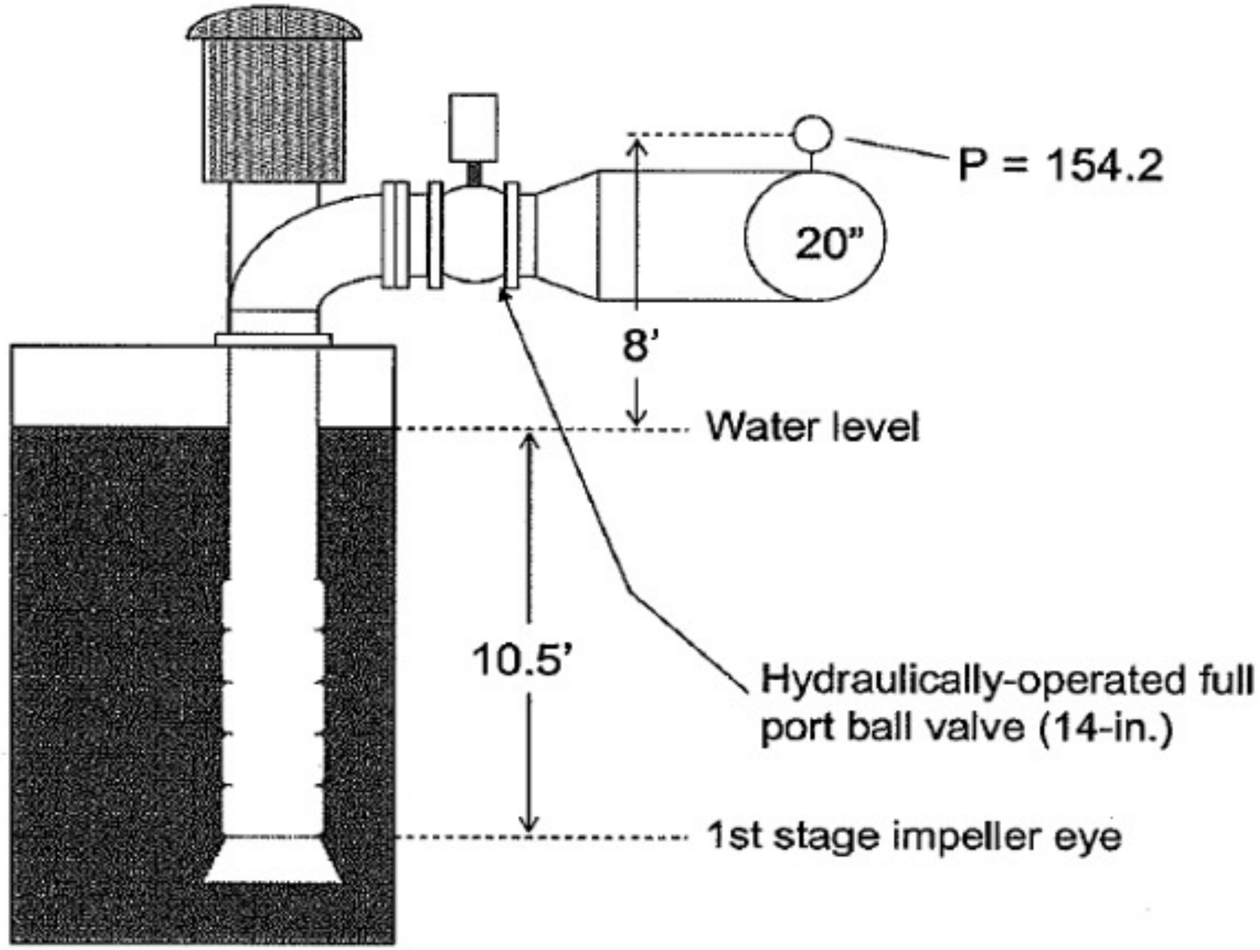
Net Positive Suction Head Required

- NPSHR is, by long-term accepted practice, the available suction head at which the developed pump head has dropped by 3% from the head that it produced with bountiful available suction head
- By definition, then, the pump performance is already degraded due to cavitation-related flow disturbance
- The actual point when cavitation actually begins can be with significantly greater available head than the pump supplier's NPSHR curve
- Two accepted approaches for developing the NPSHR curve:
  - Establish a fixed suction head, then increase flow rate until a 3% reduction in head at a particular flow rate is observed
  - Maintain a constant flow rate and gradually decrease the suction head until the developed head drops by 3%

NPSHR: Available suction head with 3% degradation in developed head



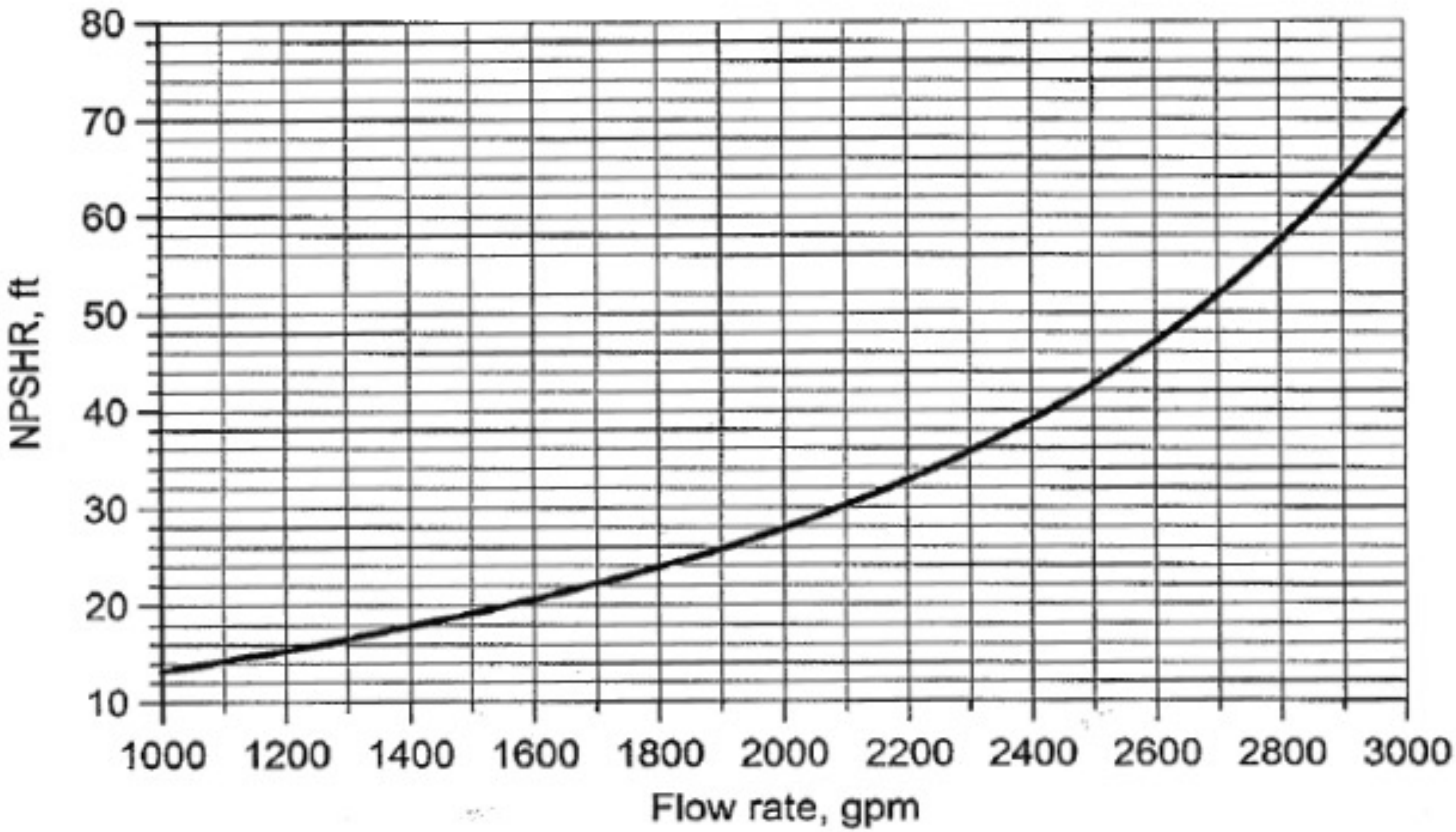
Finish water pump layout



NPSHR Curve for pump on previous slide

At what flow rate would NPSHR exceed NPSHA?

(Assume P_s = 14.7 psia and water temperature = 60 degrees F)



Calculate NPSHA

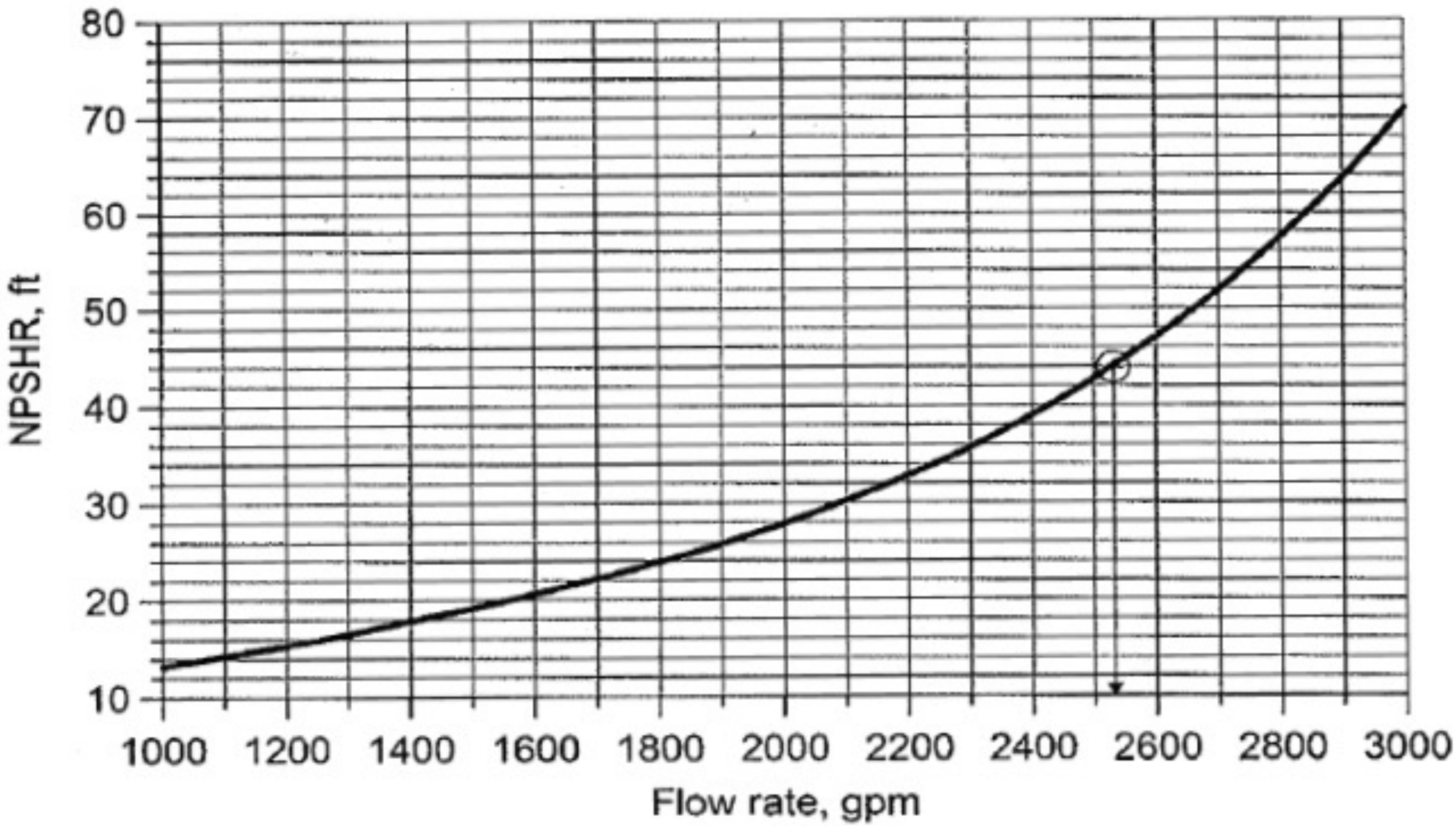
Water saturation vapor pressure at 60 F= 0.26 psia

Reference location for suction head determination is the water surface

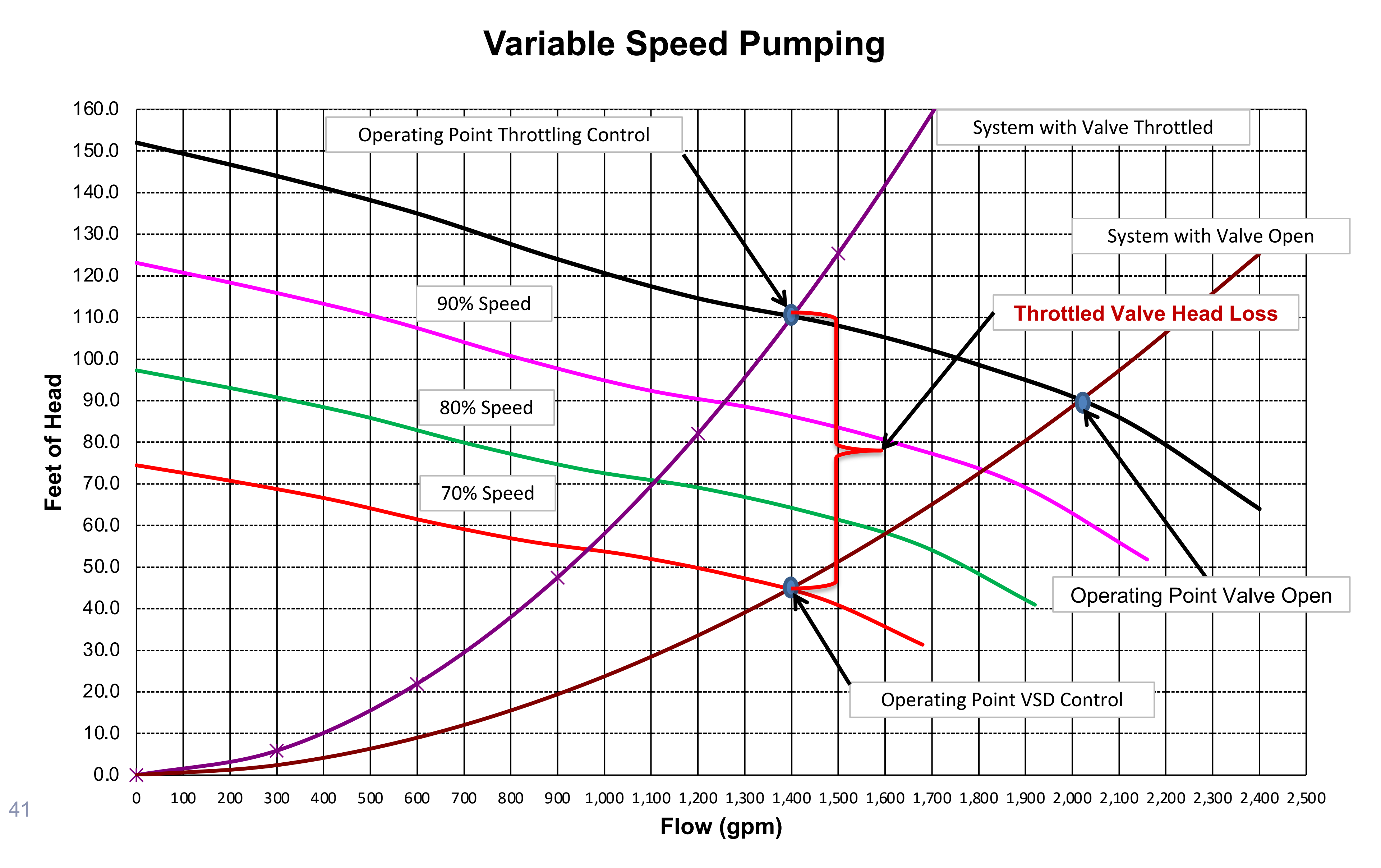
$$\text{NPSHA} = \frac{V_s^2}{2g} + \frac{2.31\ (P_s + P_a - P_v)}{\text{s.g.}} + Z_s$$

$$\text{NPSHA} = \frac{0^2}{64.352} + \frac{2.31\ (0 + 14.7 - 0.26)}{1.00} + 10.5 = \boxed{43.9\text{ ft}}$$

Answer: NPSHR would exceed NPSHA at just over 2500 gpm

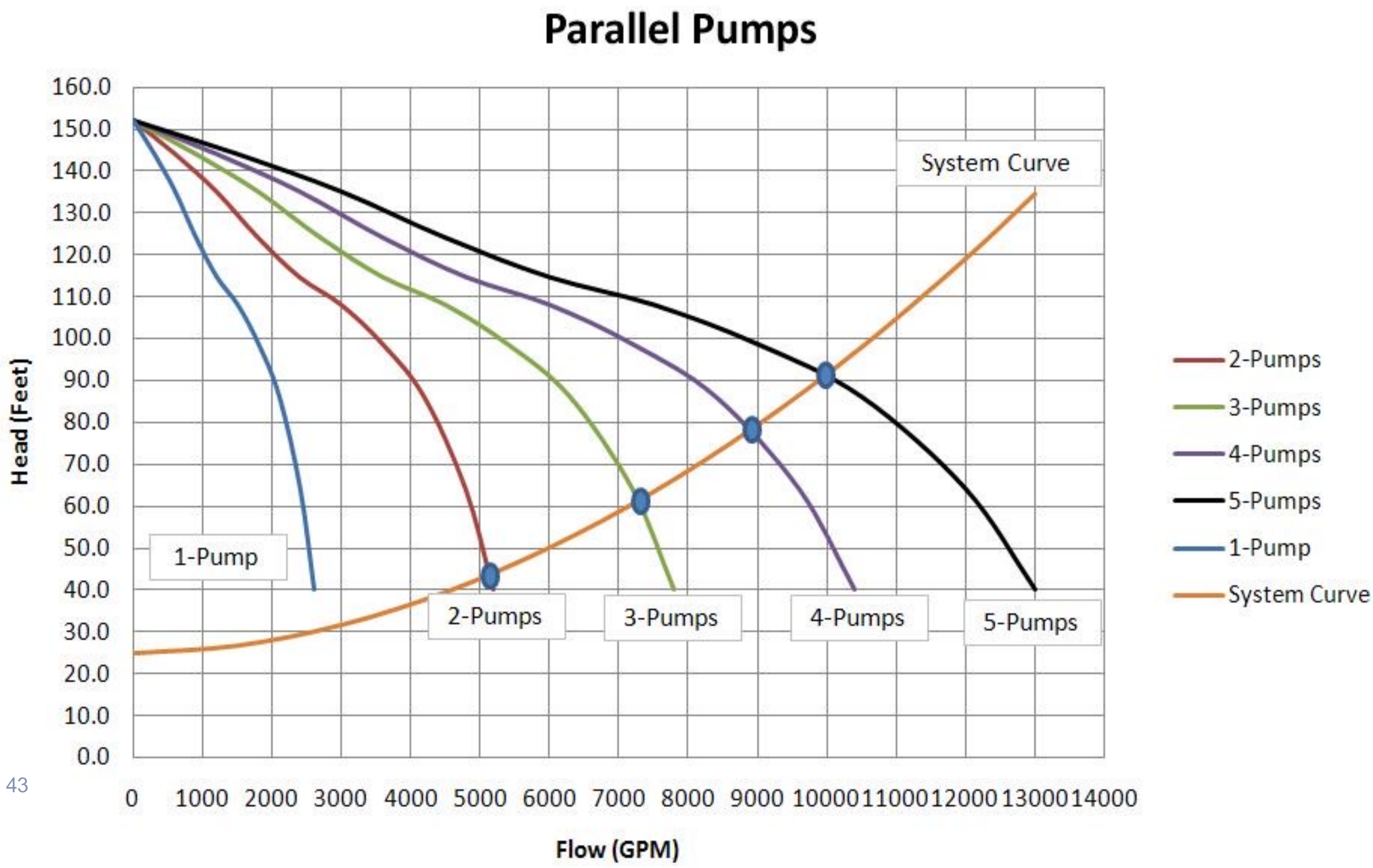


Actual Pump Data for VSD Operation

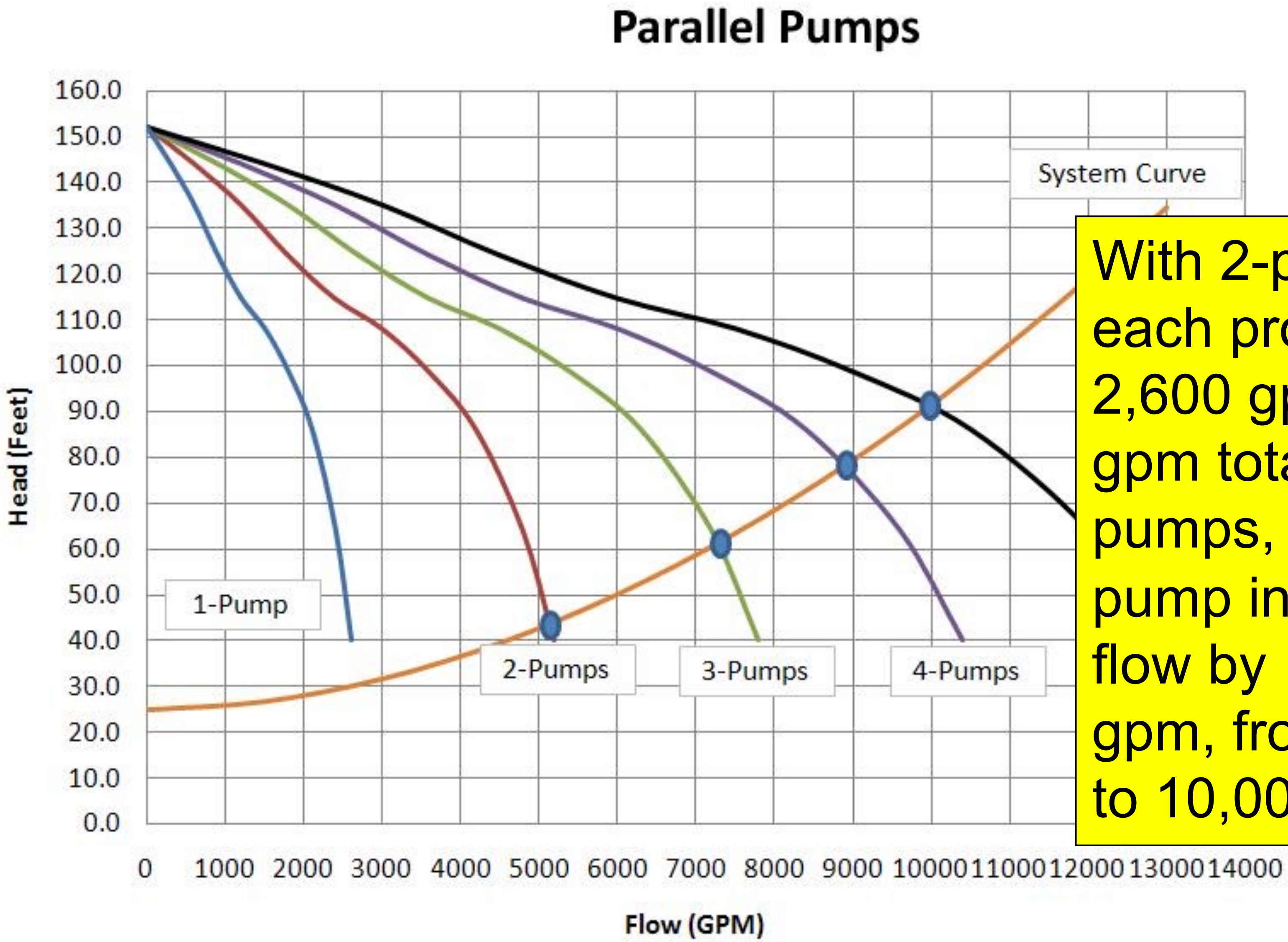


Parallel Pumping Example 1

Parallel Pumping Example



Parallel Pumping Example



With 2-pumps, each produces 2,600 gpm, 5,200 gpm total; With 5-pumps, the 5th pump increases flow by 1,100 gpm, from 8,900 to 10,000 gpm

Parallel Pumping Example

- Production only requires 4 pumps – the 5th is insurance in case one pump fails
- The opportunity is to add automatic start up controls and operate 4 pumps instead of 5
- Operating 5 pumps produces 1100 gpm of additional flow and pump head increases from 78 feet to 92 feet
- Pump efficiency is 70% and the cost of electricity is $0.08/kWh, saves 63.9 kW

Savings:

kW_{init} = (10000 gpm x 92 feet x 0.746)/(3960 x 0.7 x 0.95) = 260.6 kW

kW_{final} = (8900 gpm x 78 feet x 0.746)/(3960 x 0.7 x 0.95) = 196.7 kW

$ Saved = (260.6 – 196.7) kW x 8760 hr/yr x 0.08 $/kWh = $44,781/yr

Estimated project cost = $30,000

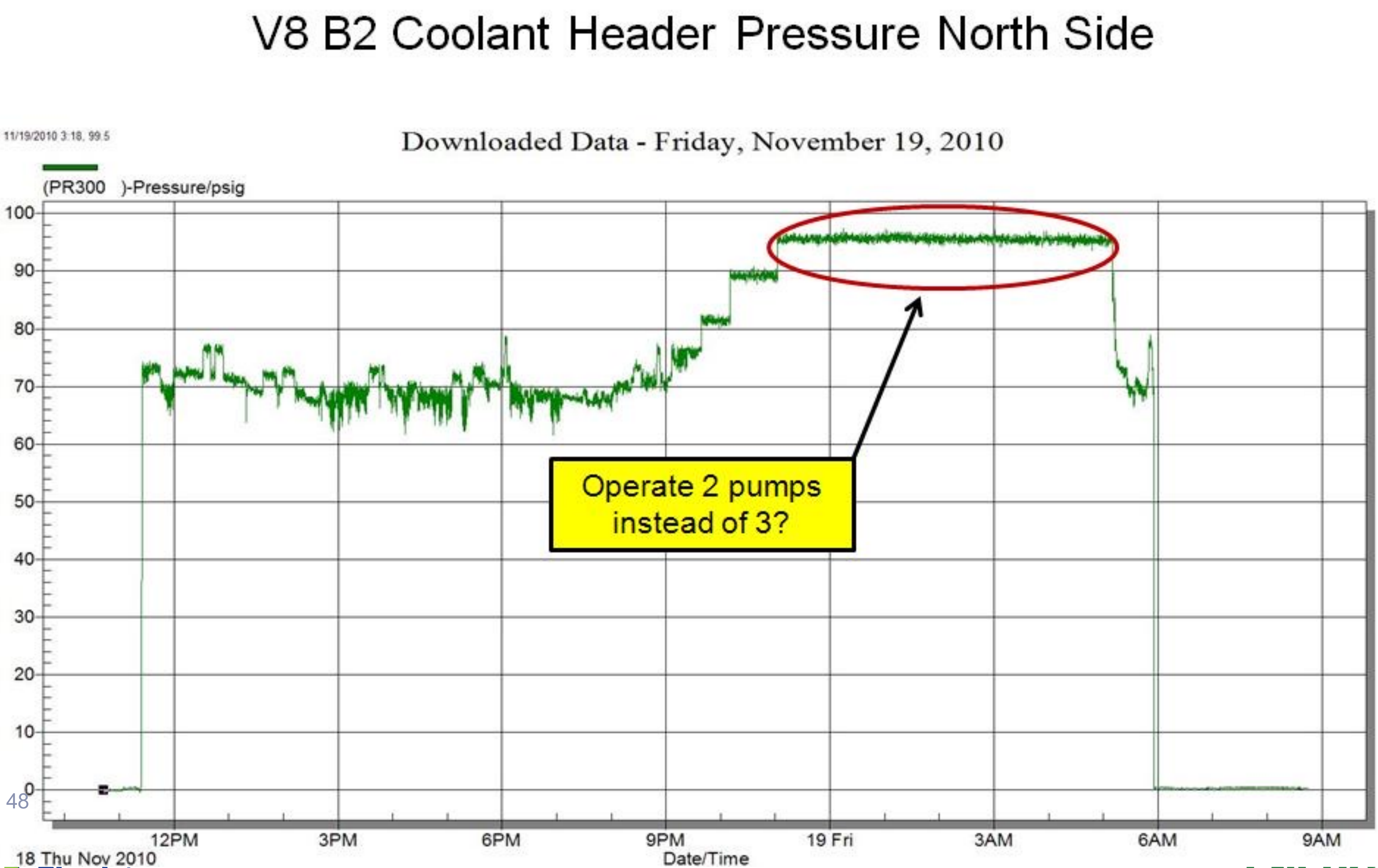
Payback = $30,000 / $44,781 = 0.7 years

Parallel Pumping Example 2

Parallel Pumping Example 2

- A coolant circulating system has five 100 HP vertical turbine pumps
- Three of the five are operated 24/7
- Many of the machining processes shut down over night
- The header pressure was logged over night and from 11 pm until 5 am the pressure was a flat 96 psig
- The typical pressure during the rest of the day is 65 psig
- The plan agreed with by the plant engineers was to turn off one pump for 6 hours/day

Parallel Pumps: Header Pressure



Parallel Pumping Example 2

Savings

kW = 100 HP x 0.6 loaded x 0.746 = 44.8 kW

Pump down time = 6 hr/day x 360 days/yr = 2160 hr/yr

Cost savings = 44.8 kW x 2160 hr/yr x 0.08 $/kWh = $7,741/yr

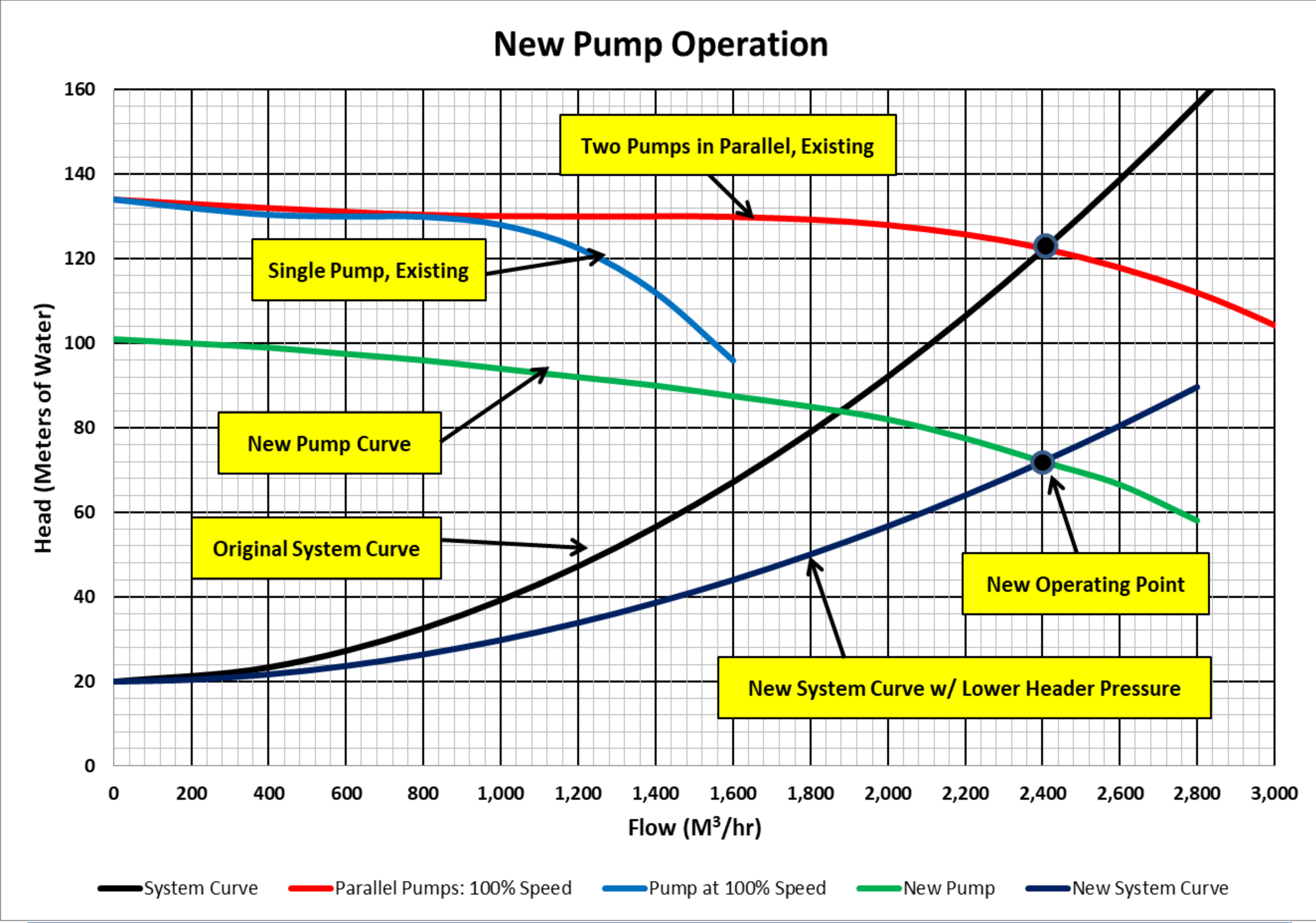
The pump will be manually started/stopped

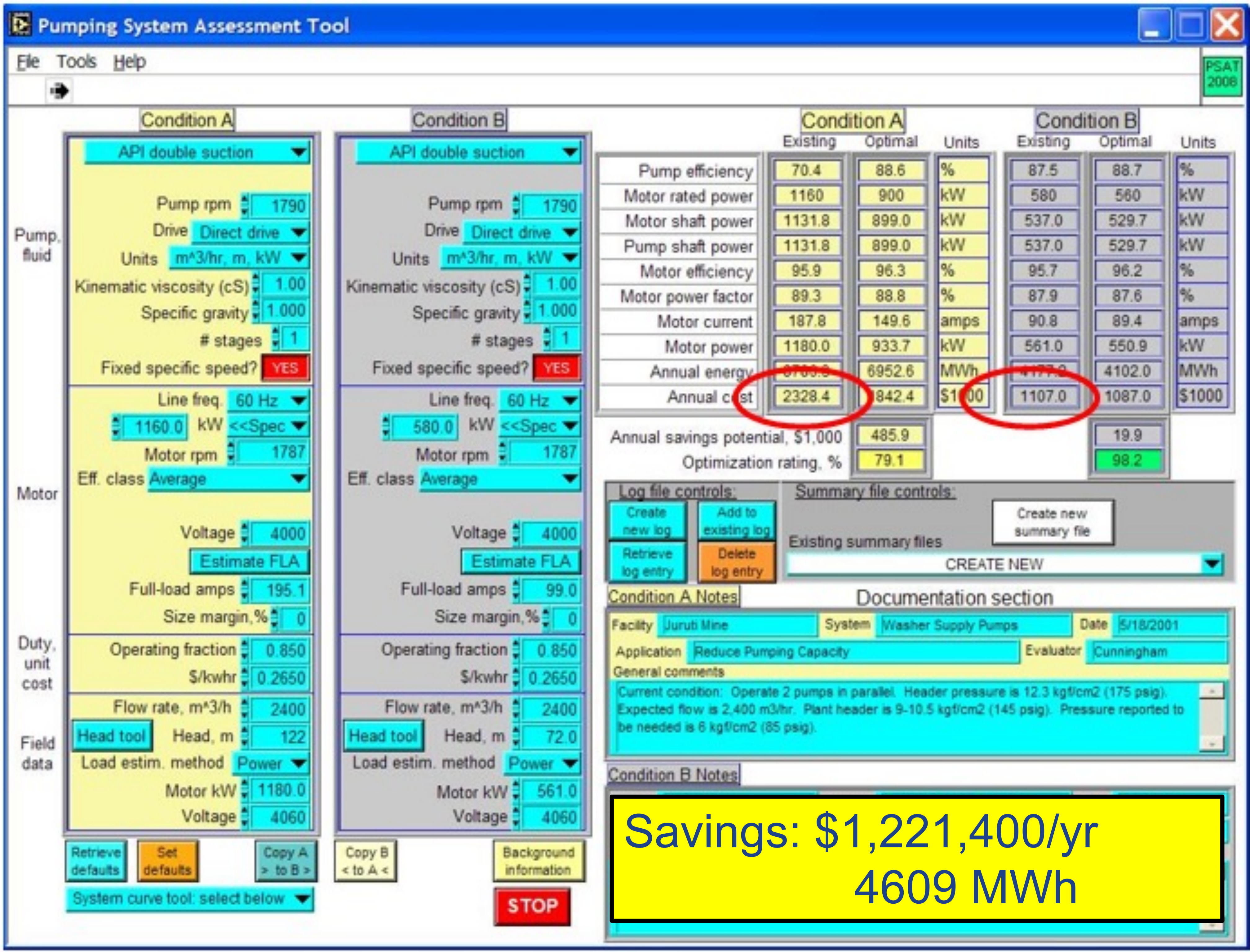
Project cost = $0

Payback = Immediate

Parallel Pumping Example 3

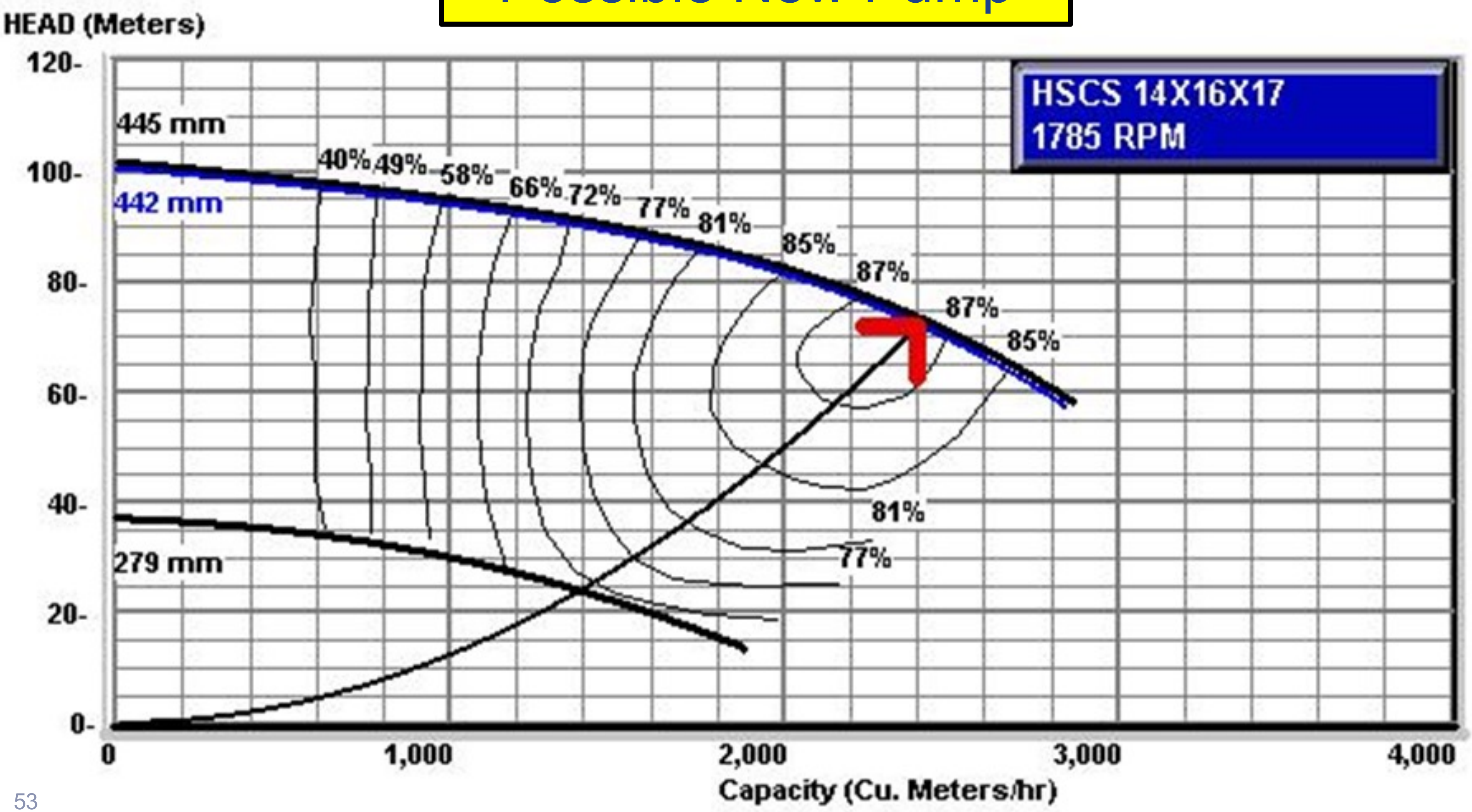
- Juruti Bauxite Mine
- Have 3 – 800 HP wash pump in parallel
- 2 pumps normally operate
- Pumps are oversized
- 50 meters of head is dropped across the control valves
- Electricity costs $0.265/kWh
- Recommended replacing one pump with one correctly sized


New Pump Operation
Two Pumps in Parallel, Existing
Single Pump, Existing
New Pump Curve
Original System Curve
New Operating Point
New System Curve w/ Lower Header Pressure
Head (Meters of Water)
160
140
120
100
80
60
40
20
0
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
2,200
2,400
2,600
2,800
3,000
Flow (M3/hr)
System Curve
Parallel Pumps: 100% Speed
Pump at 100% Speed
New Pump
New System Curve


Pumping System Assessment Tool
File Tools Help
PSAT 2008
Condition A
Condition B
API double suction
Pump rpm 1790
Drive Direct drive
Units m^3/hr, m, kW
Kinematic viscosity (cS) 1.00
Specific gravity 1.000
stages 1
Fixed specific speed? YES
Line freq. 60 Hz
1160.0 kW <<Spec
580.0 kW <<Spec
Motor rpm 1787
Eff. class Average
Voltage 4000
Estimate FLA
Full-load amps 195.1
Full-load amps 99.0
Size margin,% 0
Operating fraction 0.850
$/kwhr 0.2650
Flow rate, m^3/h 2400
Head tool
Head, m 122
Head, m 72.0
Load estim. method Power
Motor kW 1180.0
Motor kW 561.0
Voltage 4060
Pump, fluid
Motor
Duty, unit cost
Field data
Retrieve defaults
Set defaults
Copy A > to B >
Copy B < to A <
Background information
System curve tool: select below
STOP
Existing Optimal Units
Pump efficiency 70.4 88.6 % 87.5 88.7 %
Motor rated power 1160 900 kW 580 560 kW
Motor shaft power 1131.8 899.0 kW 537.0 529.7 kW
Pump shaft power 1131.8 899.0 kW 537.0 529.7 kW
Motor efficiency 95.9 96.3 % 95.7 96.2 %
Motor power factor 89.3 88.8 % 87.9 87.6 %
Motor current 187.8 149.6 amps 90.8 89.4 amps
Motor power 1180.0 933.7 kW 561.0 550.9 kW
Annual energy 6952.6 MWh 4102.0 MWh
Annual cost 2328.4 1107.0 1087.0 $1000
Annual savings potential, $1,000 485.9 19.9
Optimization rating, % 79.1 98.2
Log file controls:
Create new log
Add to existing log
Retrieve log entry
Delete log entry
Summary file controls:
Create new summary file
Existing summary files
CREATE NEW
Condition A Notes
Documentation section
Facility Juruti Mine
System Washer Supply Pumps
Date 5/18/2001
Application Reduce Pumping Capacity
Evaluator Cunningham
General comments
Current condition: Operate 2 pumps in parallel. Header pressure is 12.3 kgf/cm2 (175 psig). Expected flow is 2,400 m3/hr. Plant header is 9-10.5 kgf/cm2 (145 psig). Pressure reported to be needed is 6 kgf/cm2 (85 psig).
Condition B Notes
Savings: $1,221,400/yr
4609 MWh

Parallel Pumping Example 3

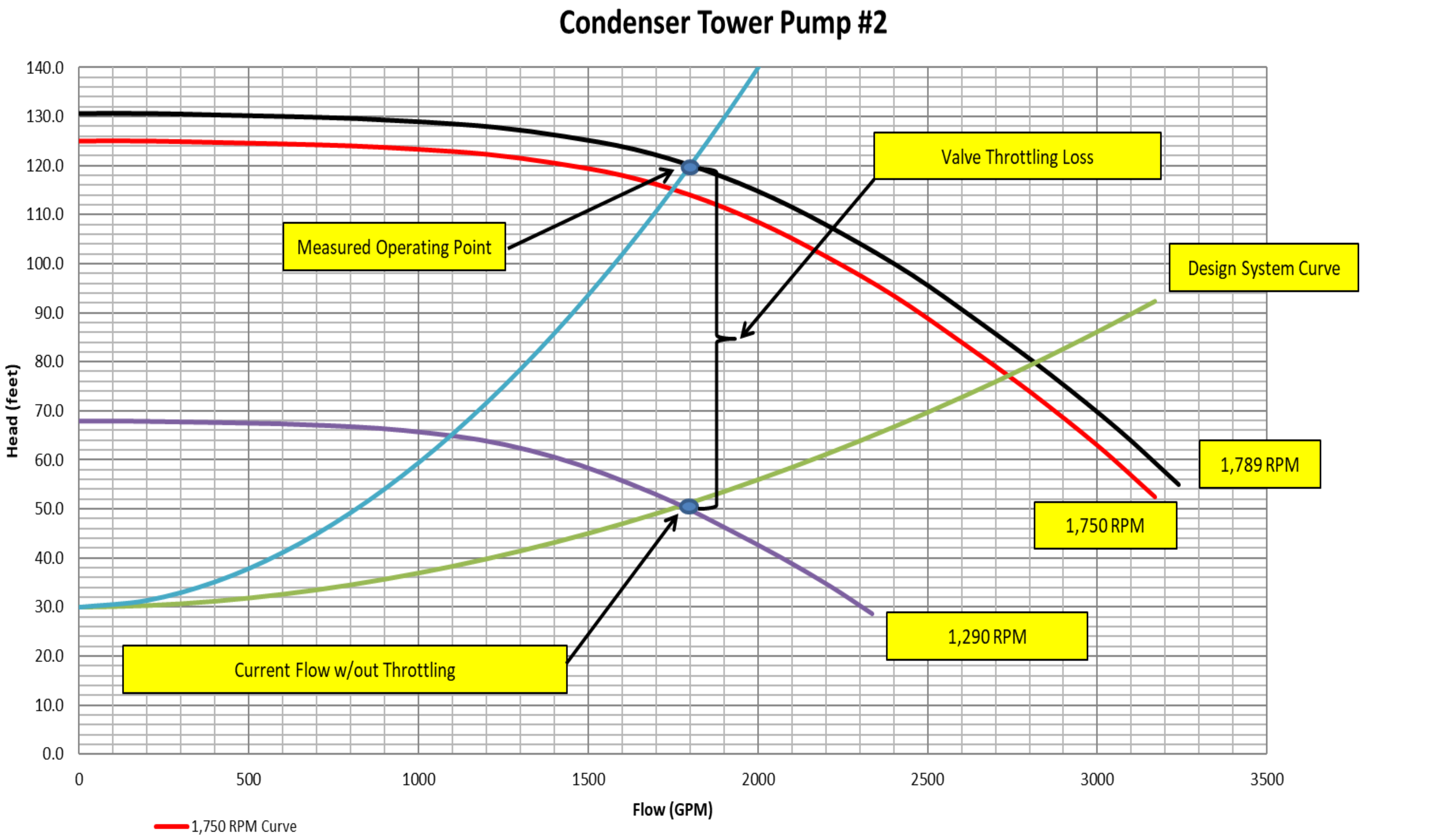
Possible New Pump



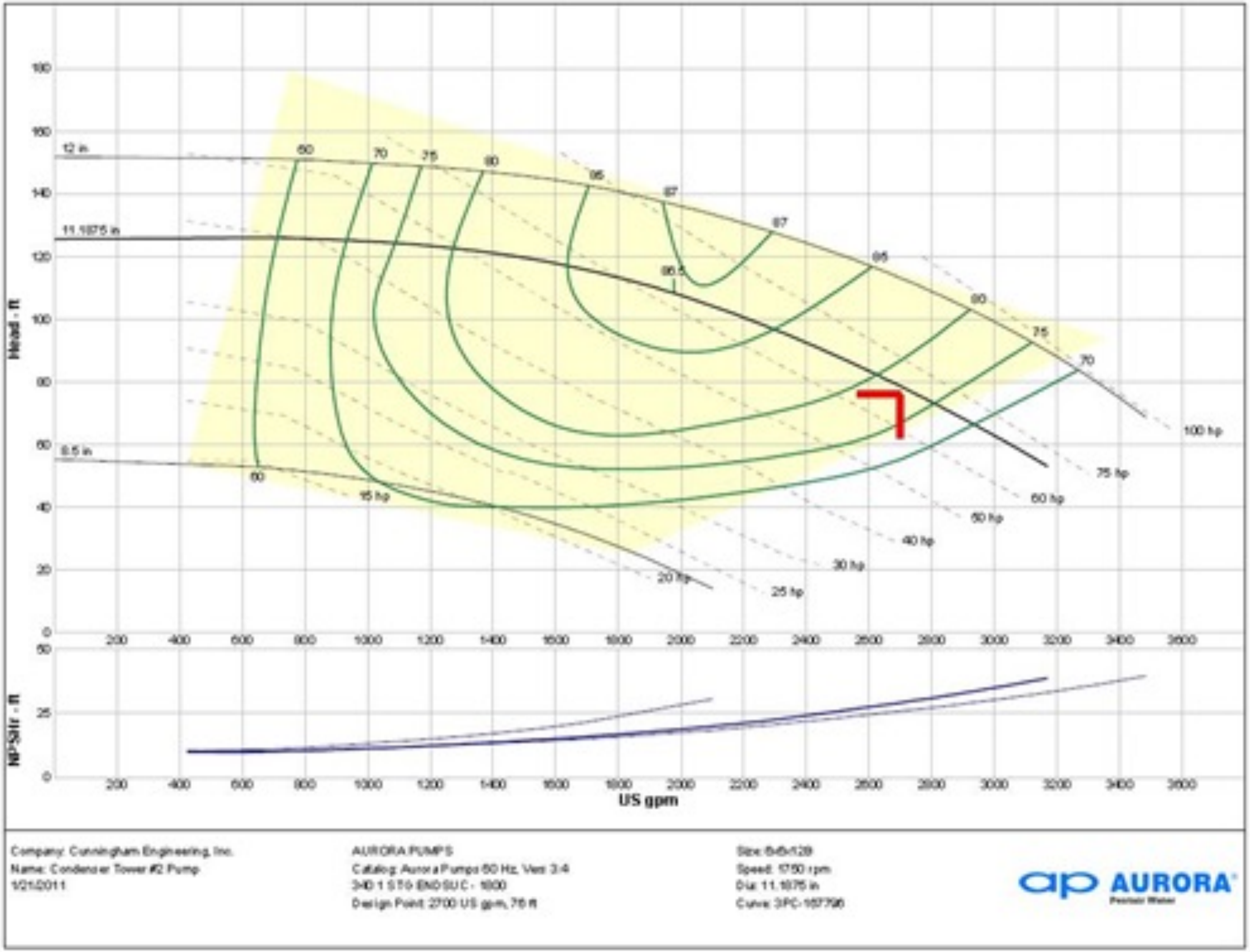
Throttled Pump Example 1

- Condenser Tower Pump #2
- One 100 HP end suction centrifugal pump
- Pump is oversized
- Butterfly valve at discharge is 30% open
- With VFD pump speed can be reduced from 1789 rpm to 1290 rpm and valve opened
- Motor input power falls from 54.9 kW to 24.7 kW
- Saves 241,667 kWh worth $17,400/year
- Cost $15,000 Payback 0.9 yrs

Throttled Pump Example 1



Throttled Pump Example 1



Throttled Pump Example 1

Throttled Pump Example 1
Last modified: Aug 2, 2023

System Setup | **Assessment** | Diagram | Report | Sankey | Calculators

Explore Opportunities *Novice View* | Modify All Conditions *Expert View*

Install VFD Open Valve *Selected Scenario* | View / Add Scenarios

SELECT POTENTIAL ADJUSTMENT PROJECTS

Select potential adjustment projects to explore opportunities to increase efficiency and the effectiveness of your system.

Add New Scenario

Modification Name: Install VFD Open Valve

☑ Install VFD

Baseline		Modifications	
Flow Rate	1,771 gpm	Flow Rate	1771 gpm
Head	116 ft	Head (Calculate Head)	51 ft
Motor Drive	Direct Drive	Drive Efficiency	97 %
Pump Type	End Suction ANSI/API	Pump Efficiency (Optimize Pump)	74.1 %

The efficiency of your pump has been calculated based on your system setup. Either directly modify your efficiency or click **"Optimize Pump"** to estimate your pump efficiency based on a different pump type.

☐ Adjust Operational Data

RESULTS | SANKEY | HELP

	Baseline	Install VFD Open Valve
Percent Savings (%)	— —	54.0%
Pump efficiency (%)	74.1	74.1
Motor rated power (hp)	100	100
Motor shaft power (hp)	70.1	31.8
Pump shaft power (hp)	70.1	30.8
Motor efficiency (%)	95.1	93.1
Motor power factor (%)	83.7	66.5
Percent Loaded (%)	70	32
Drive efficiency (%)	100	97
Motor current (A)	83	48
Motor power (kW)	55	25.5
Annual CO2 Emissions (tonne CO_2)	**189.6**	**87.7**
Annual CO2 Emissions Savings (tonne CO_2)	**—**	**101.9**
Annual Energy (MWh)	**440**	**204**
Annual Energy Savings (MWh)	**—**	**236**
Annual Cost ($)	**31,685**	**14,660**
Annual Savings ($)	**—**	**17,025**

The End for Session 4