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Pumping System Assessment

Week 2: Pump Curves and System Curves

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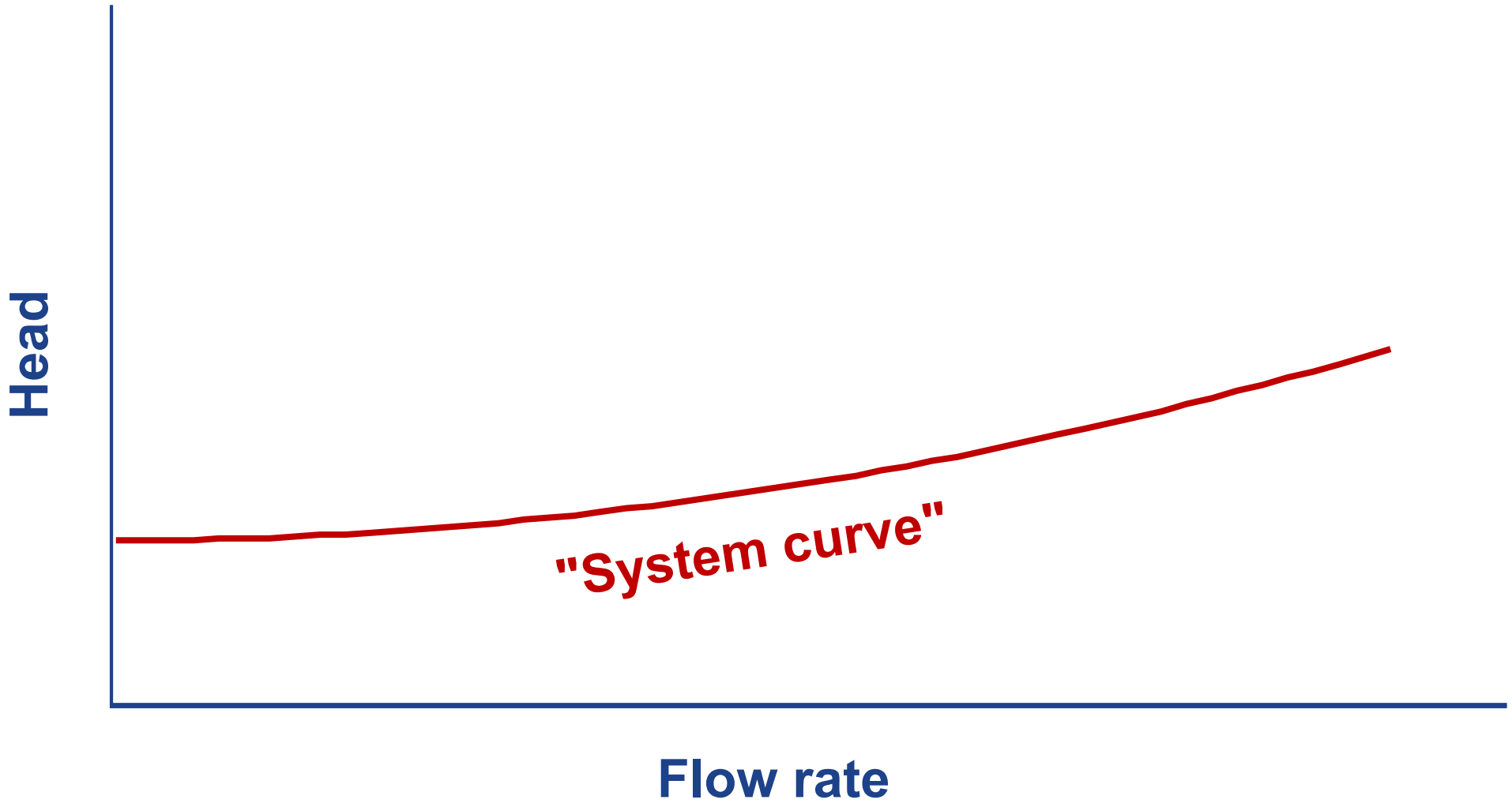
Homework 1 review

Pump Curves & System Curves

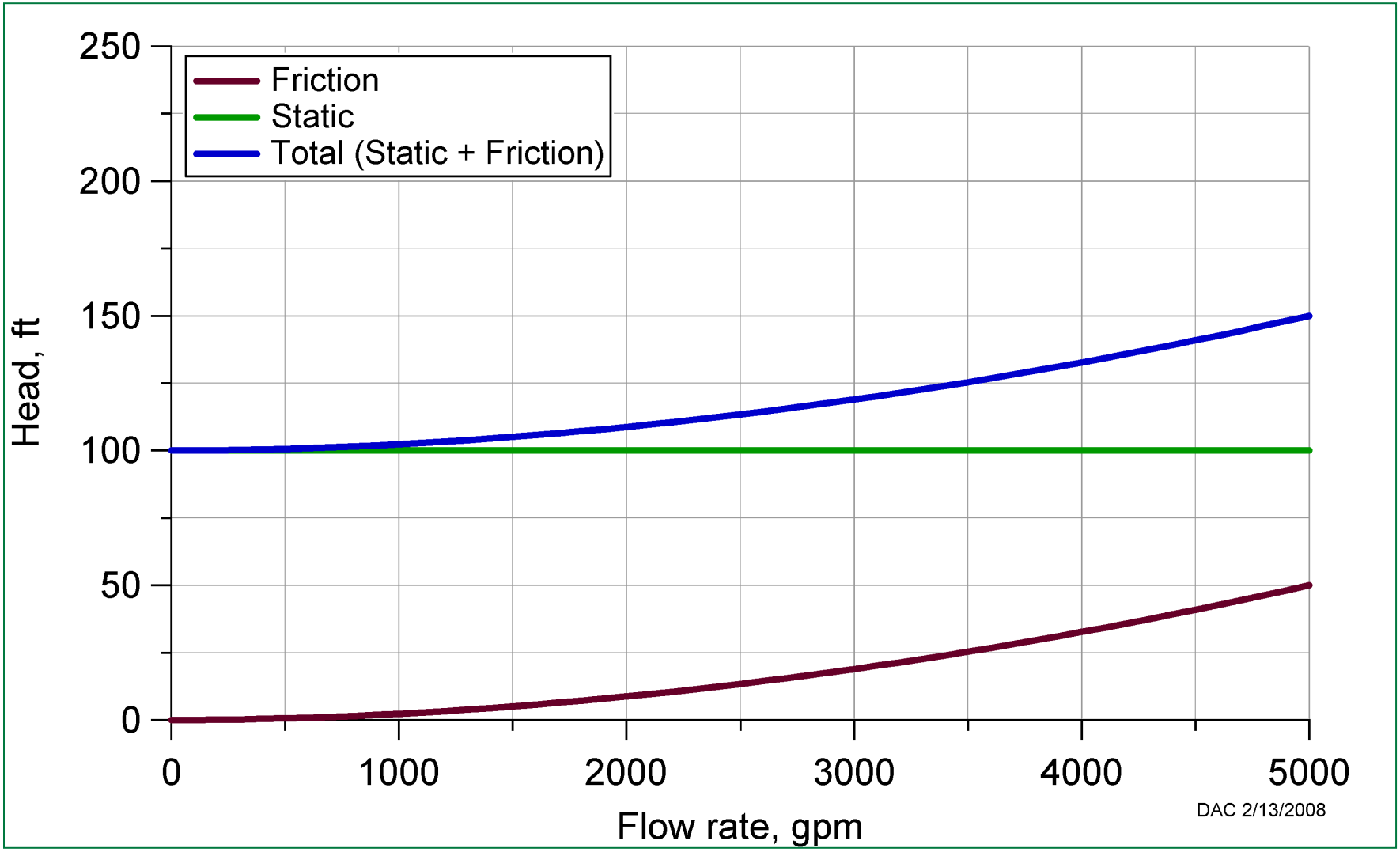
Let's start with the system curve



System curves show the two fundamental components - the static head and the frictional head

- Static head refers to the change in elevation from the suction to the discharge
- Tank over-pressures must be included in calculations
- This is basically the change in potential energy of fluid as it moves from the suction tank to the discharge tank
- Closed systems typically do not have static head
- Static heads can be positive, negative or zero

System curves are made up of two fundamental components - static head and frictional head



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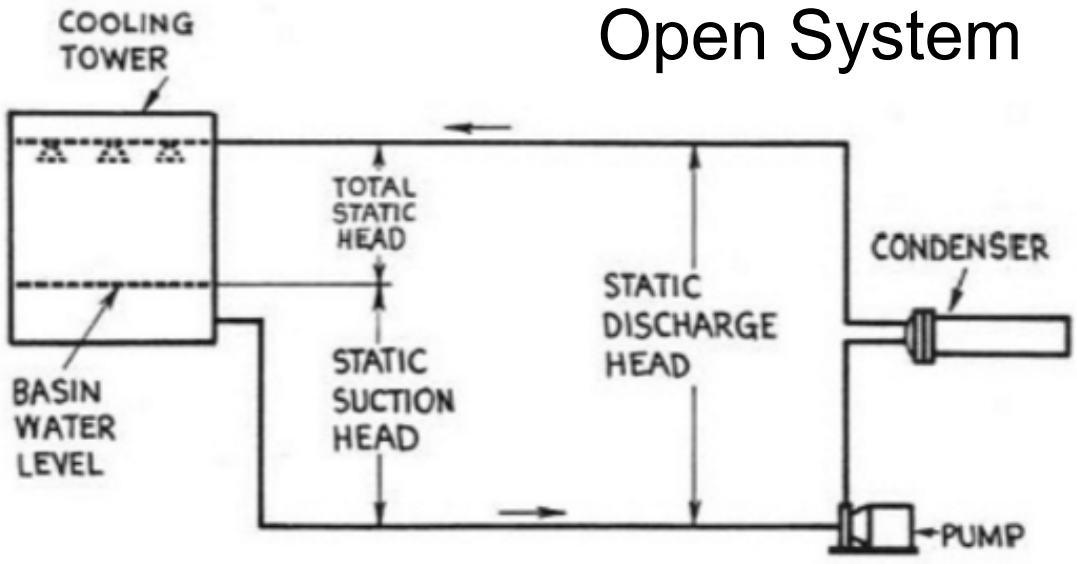
Poll question

- Is it possible for a closed system to have some static head?
  - A. Yes
  - B. No

Open and Closed Piping Systems

- Piping systems for water transmission can be considered in two general categories:
  - Open systems
  - Closed or sealed systems
- Open systems are piping circuits, pumped or gravity circulated, that are open to the atmosphere at some point
- Closed systems are designed and installed as hermetically sealed systems that offer several advantages

Open System



Poll question

- Based on the results of your prescreening efforts, are the pumping systems in your plant:
  - Open
  - Closed
  - Both
  - Don’t know

System Curves

System curves display the total head required to move different amounts of flow through the piping system

System curve equations:

$$H_{total} = H_{static} + k'Q^{1.9}$$

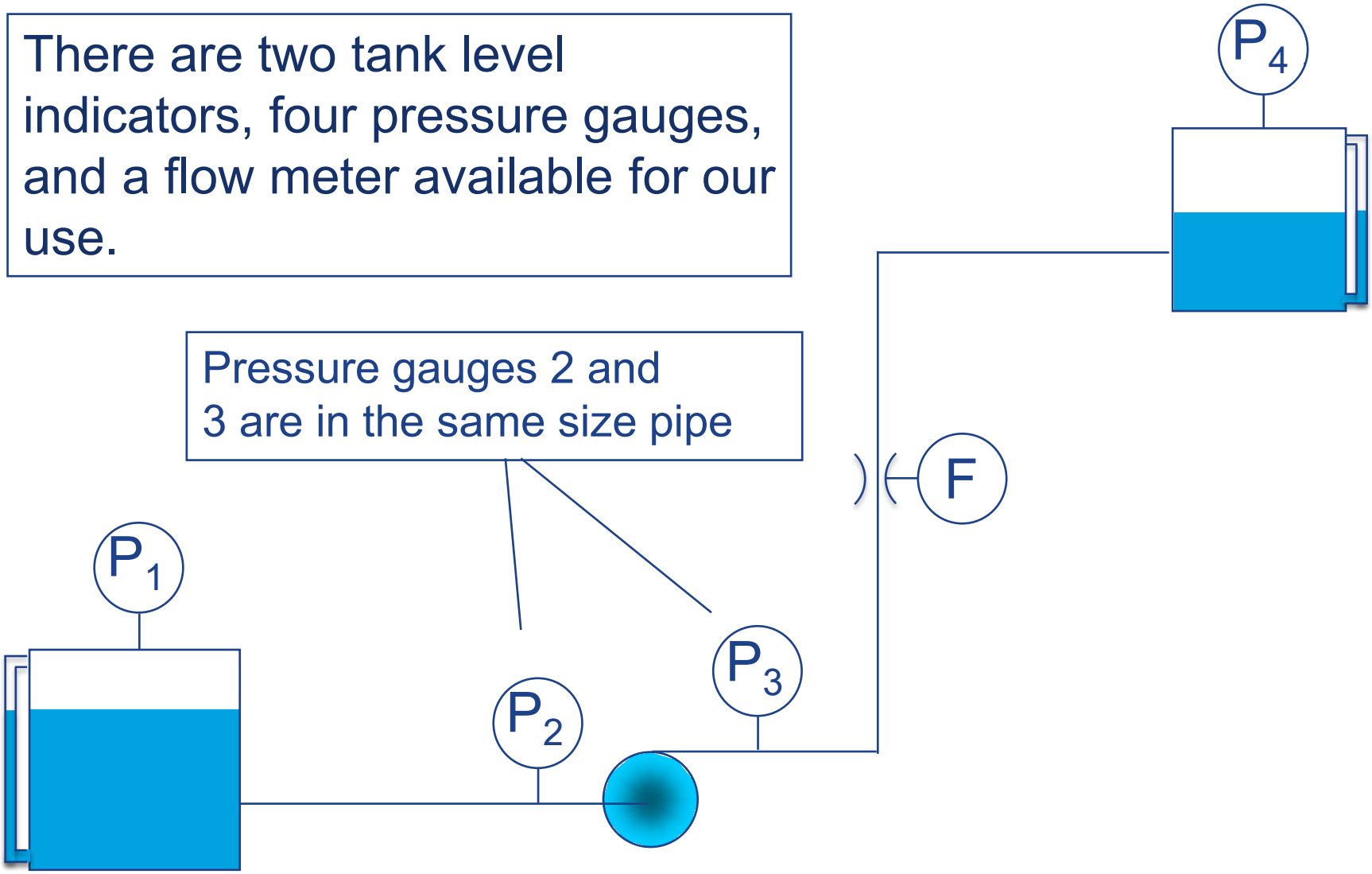
Closed piping systems have zero static head

Open piping systems generally have some static head

We'll use this system as an example: water is pumped from one tank to another

There are two tank level indicators, four pressure gauges, and a flow meter available for our use.

Pressure gauges 2 and 3 are in the same size pipe



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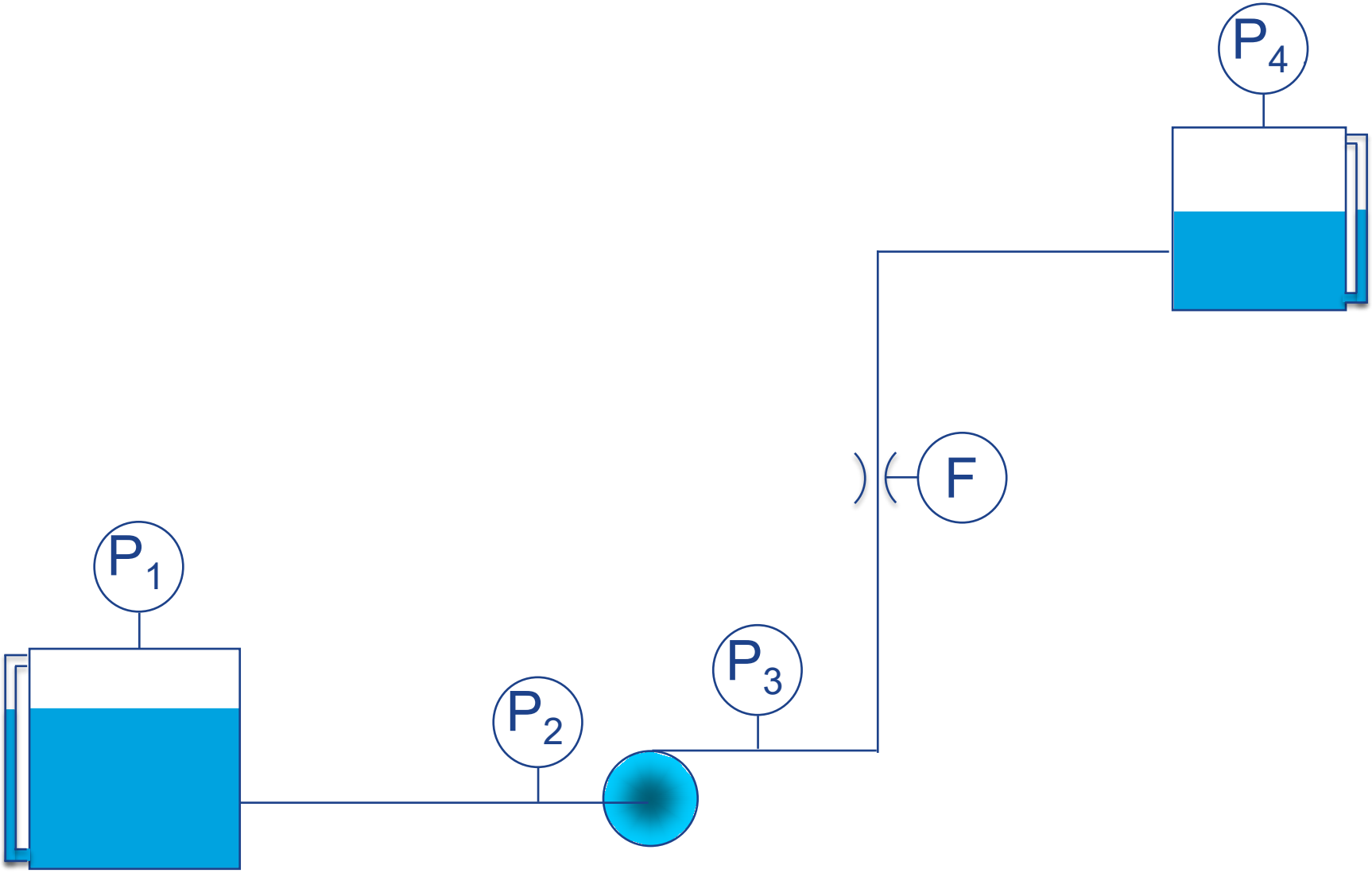


There are two basic elements of system head-capacity performance curves

$$H_{tot} = H_s + H_f$$ (H_{tot} is the total head)

- Static head, H_s (pressure, elevation) is constant with flow rate
- Frictional head, H_f varies with the square of the flow rate

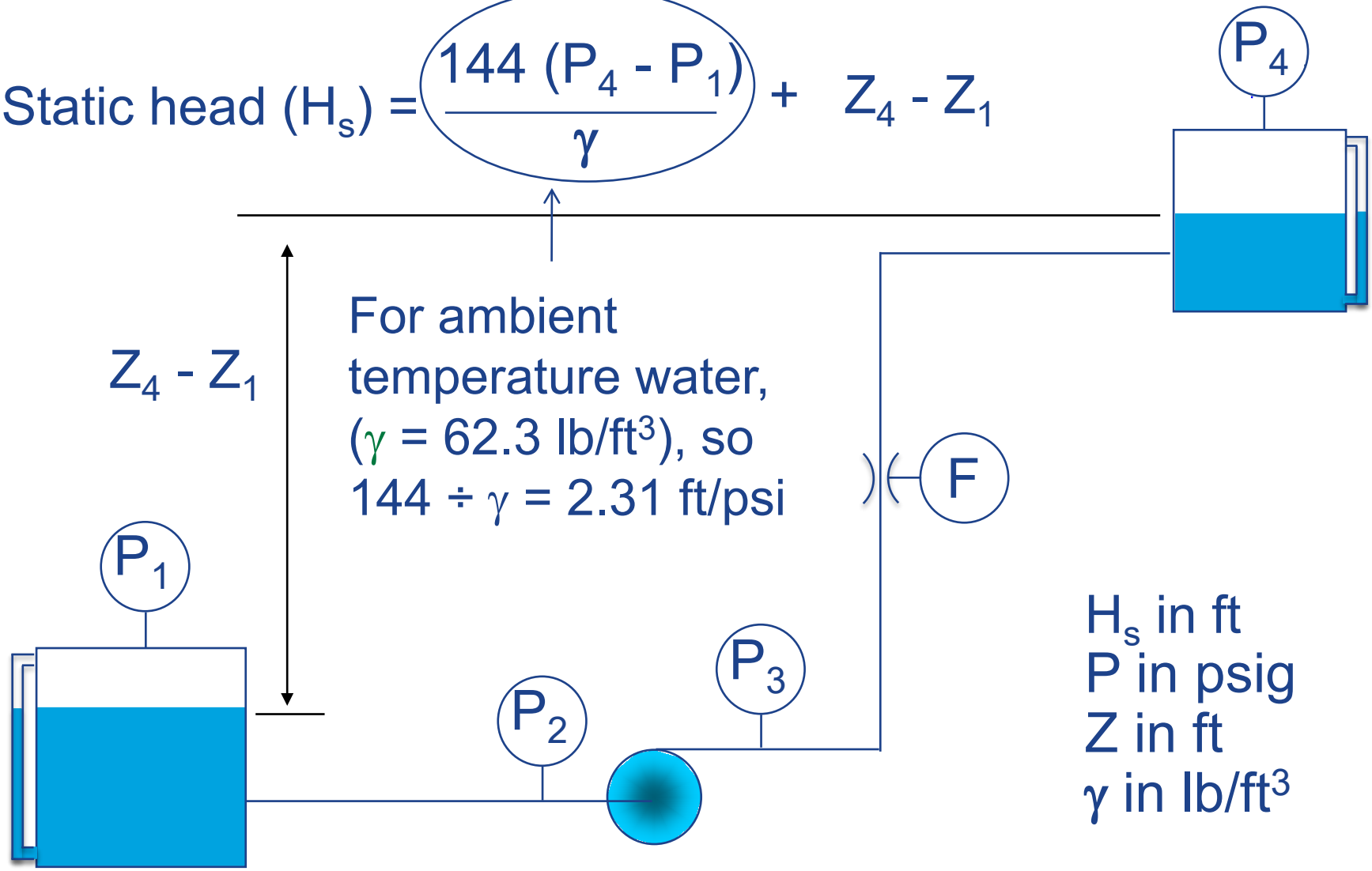
Nobody sells static or frictional head meters

Fortunately, there's a back door, and there are only two pieces of information needed to unlock it:

1) The static head, which we can estimate, and
2) The total head at a single flow rate, which we can measure

The static head is made up of elevation, and sometimes pressure components

$$\text{Static head } (H_s) = \frac{144\,(P_4 - P_1)}{\gamma} + Z_4 - Z_1$$

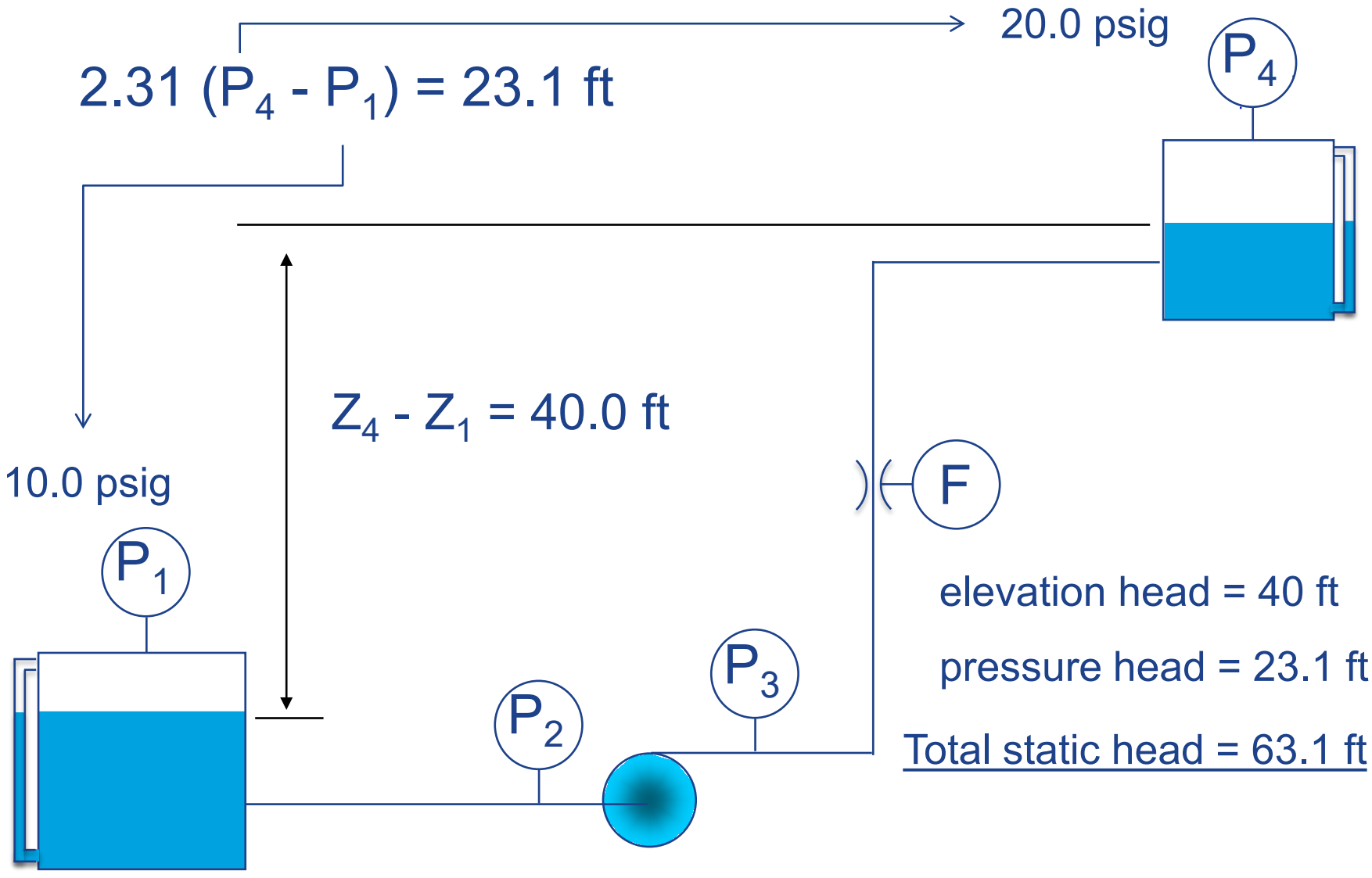


$Z_4 - Z_1$

For ambient temperature water, (γ = 62.3 lb/ft^3), so 144 ÷ γ = 2.31 ft/psi

H_s in ft
P in psig
Z in ft
γ in lb/ft^3

The static head is made up of elevation, and sometimes pressure components



Now that we've got the static head estimated, we can go after the frictional head

Calculating the frictional head at one flow rate

$$H_{tot} = H_s + H_f \qquad \text{or}$$

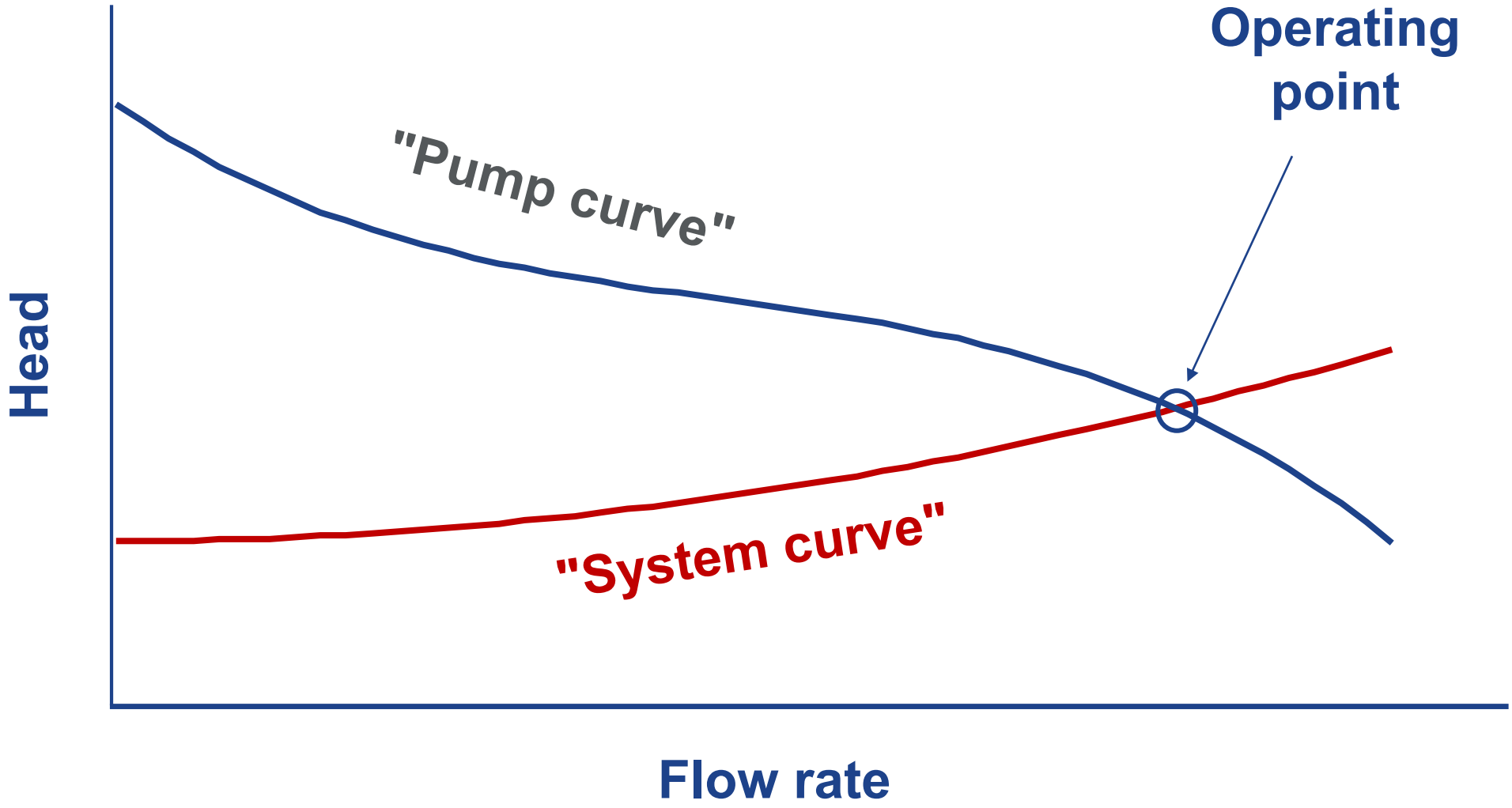
$$H_f = H_{tot} - H_s$$

So, a single point measurement of flow and total head, along with knowledge of the static head, gives us the frictional head <u>at that flow rate</u>

Our example system - how can we get the total head (H_{tot})?

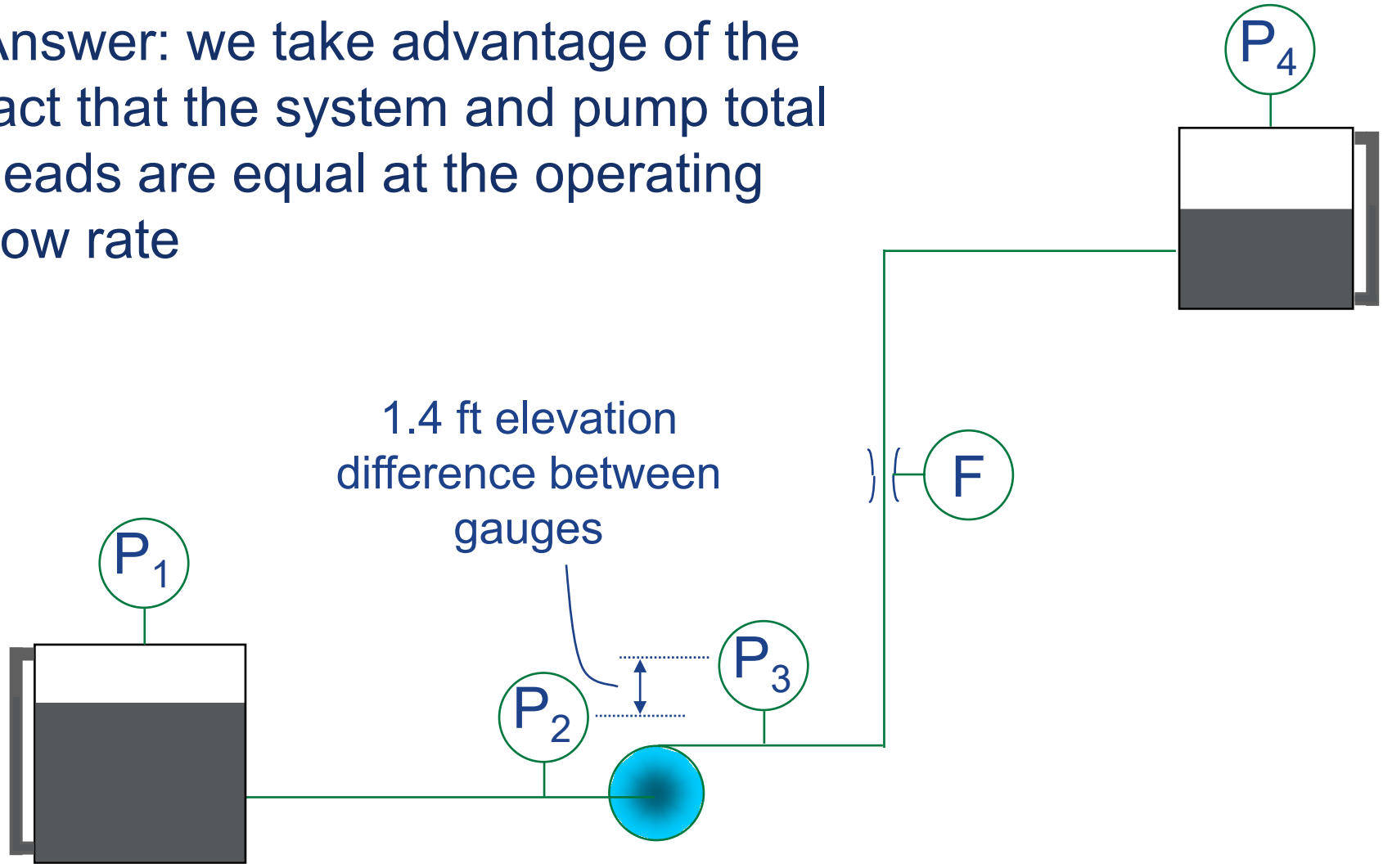
We take advantage of one inviolable fact for centrifugal pumping systems

The system operating point is at the intersection of the pump and system head-capacity curves



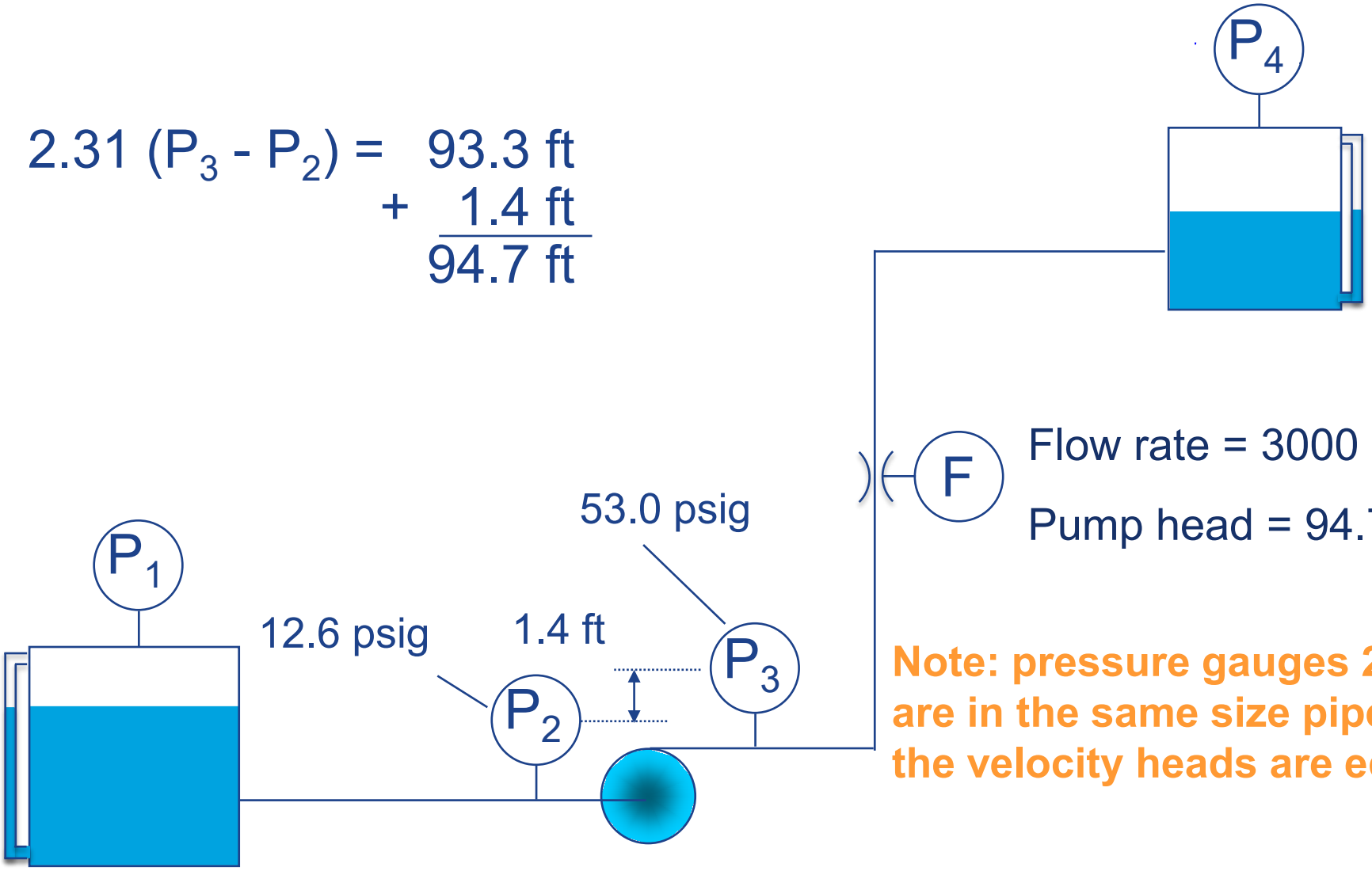
and we can measure the pump head

Answer: we take advantage of the fact that the system and pump total heads are equal at the operating flow rate



The system total head at any flow rate is the same thing as the pump total head - so we measure the pump head

$$2.31\,(P_3 - P_2) = 93.3\text{ ft} + 1.4\text{ ft} = 94.7\text{ ft}$$

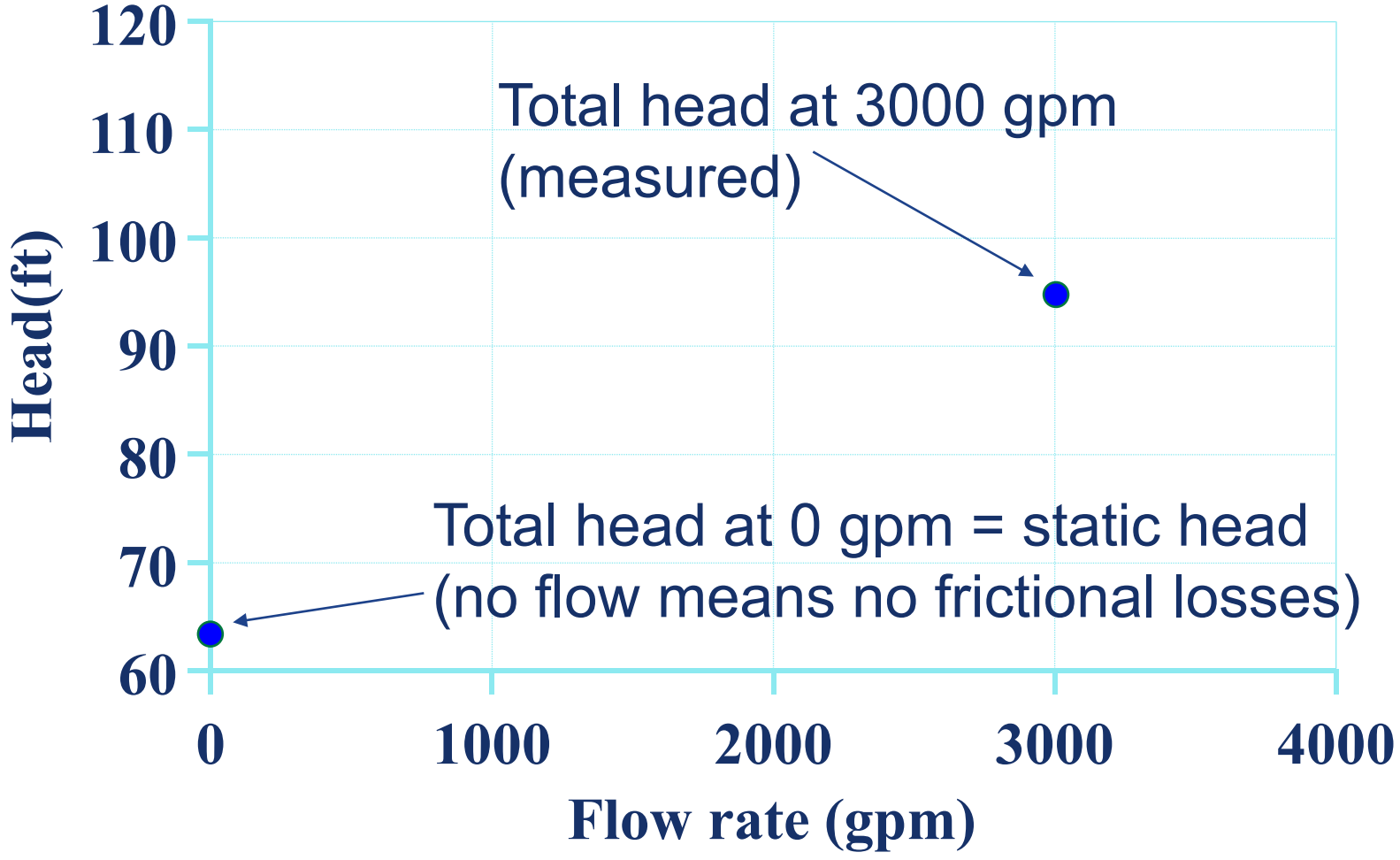


Flow rate = 3000 gpm

Pump head = 94.7 ft

Note: pressure gauges 2 & 3 are in the same size pipe, so the velocity heads are equal

We have two points on the system curve; now we just have to figure out how to connect them



A little algebra….

$$H_2 = H_s + KQ_2^2$$

$$H_1 = H_s + KQ_1^2$$

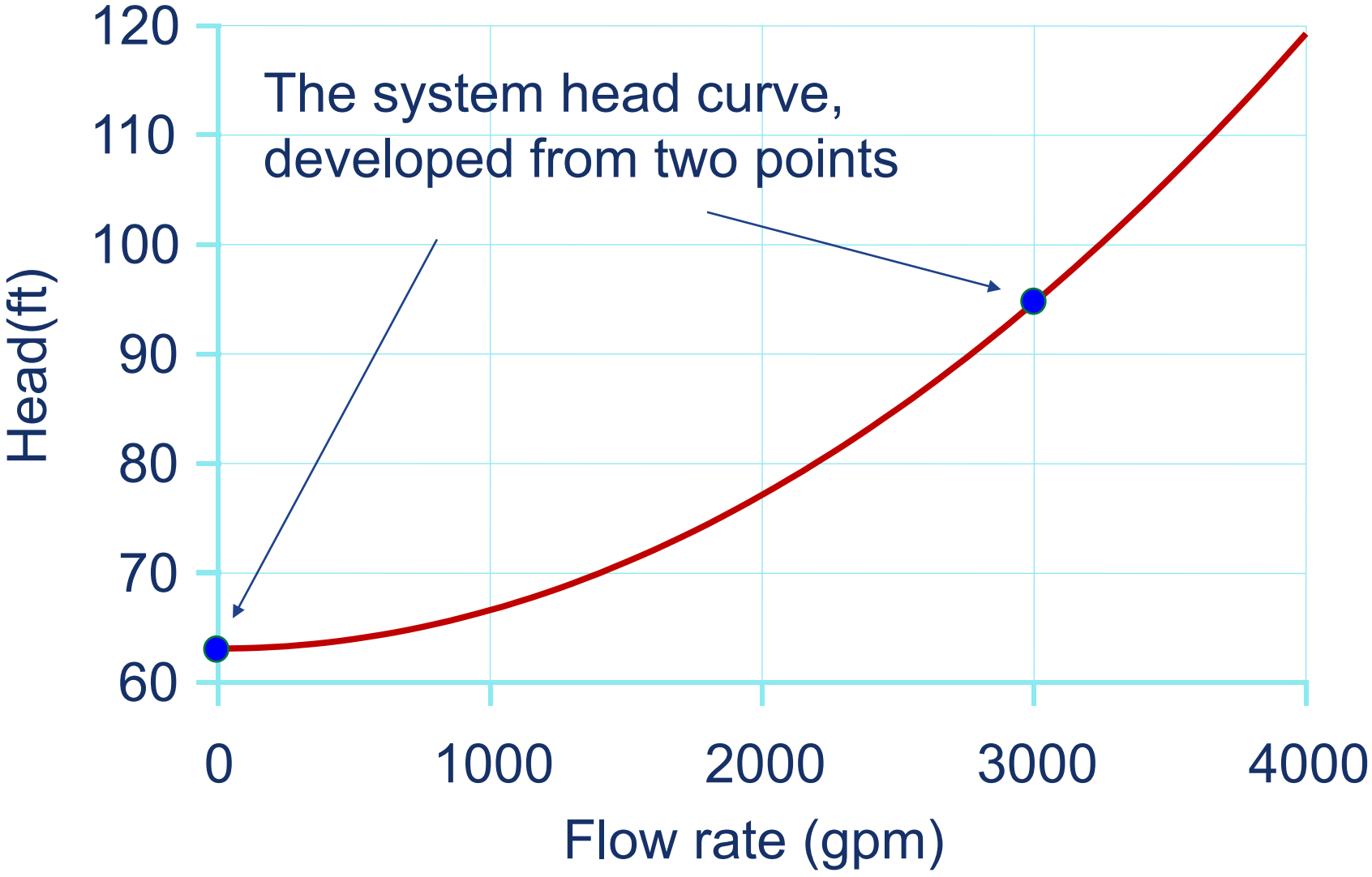
Subtracting yields

$$H_2 - H_1 = K(Q_2^2 - Q_1^2), \text{ so}$$

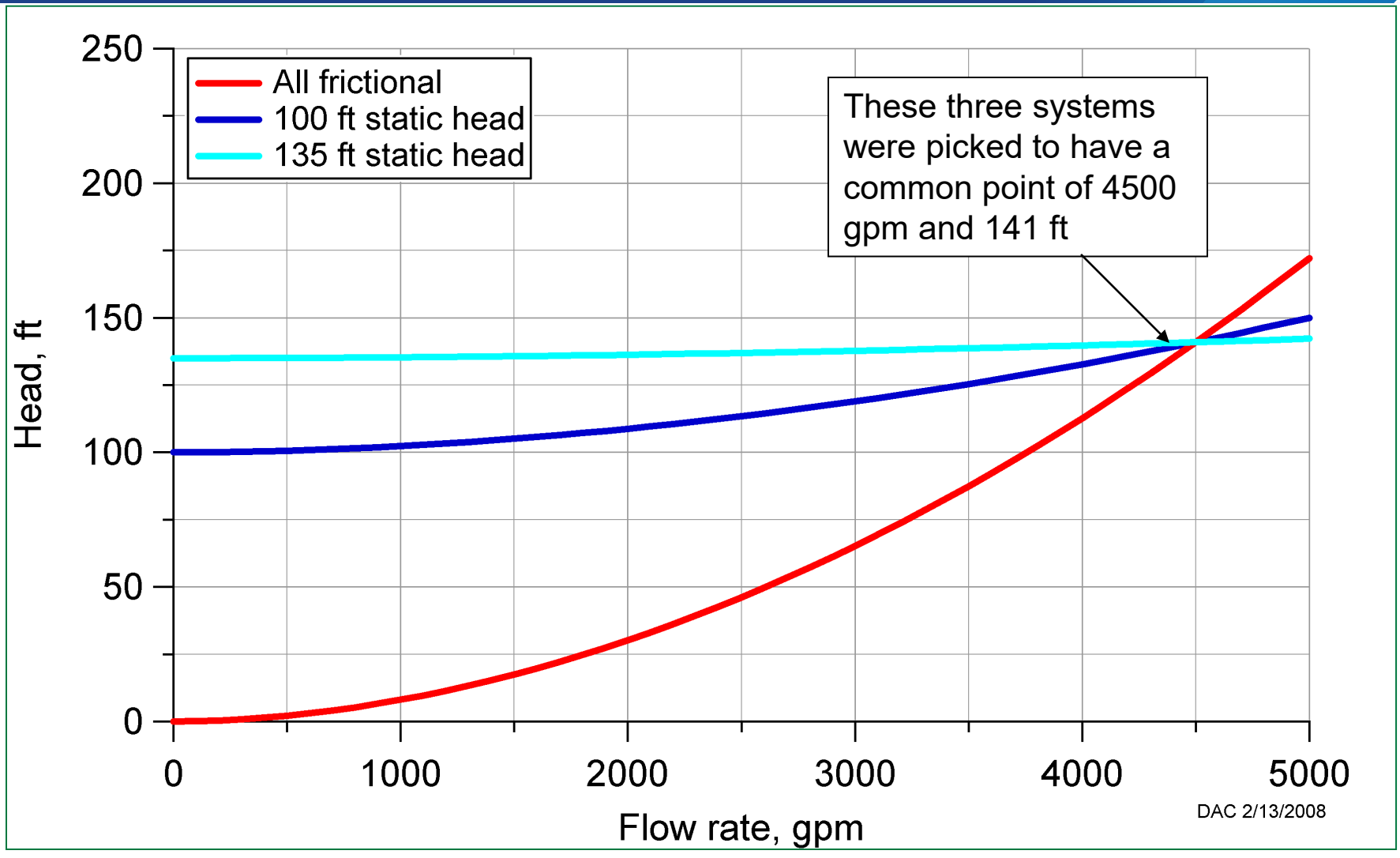
$$\boxed{K = \frac{(H_2 - H_1)}{(Q_2^2 - Q_1^2)} \quad \text{and } H_s = H_1 - KQ_1^2}$$

Although the static head is known in this case, any two flow and head combinations will suffice.

The resultant system curve



System head curves for three different systems



NOTE: These are three <u>different</u> systems

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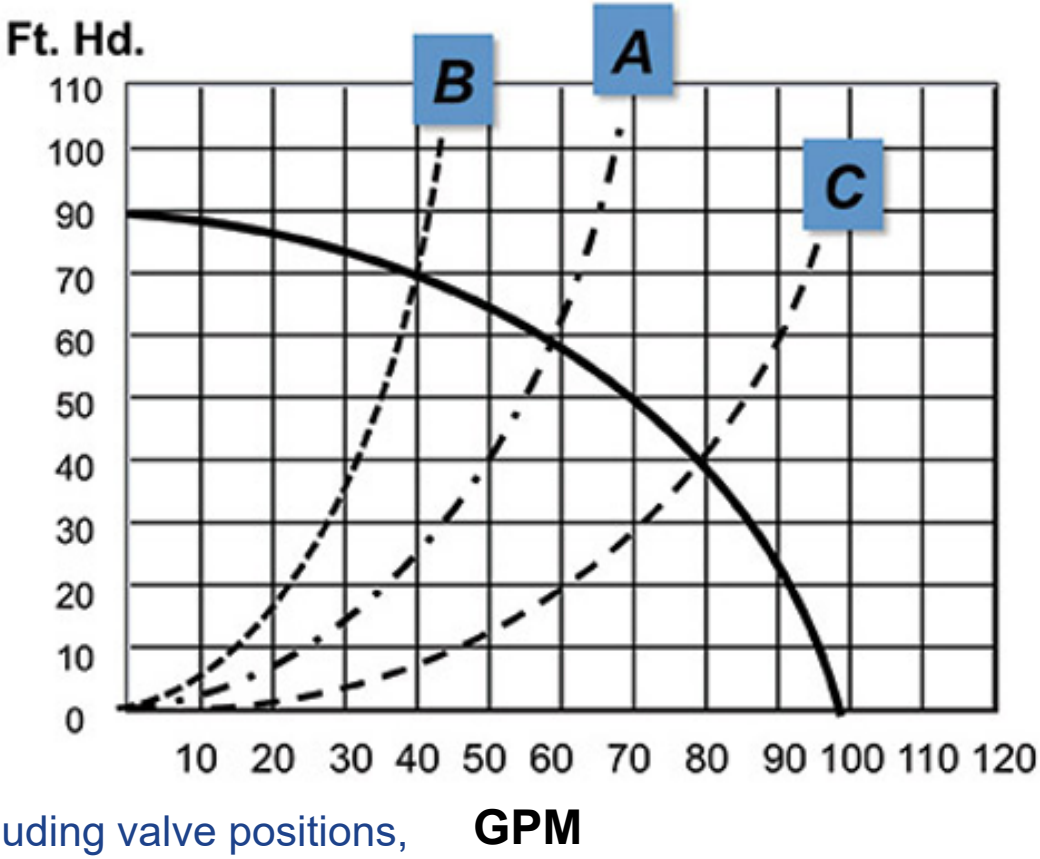
Where do system curves come from?

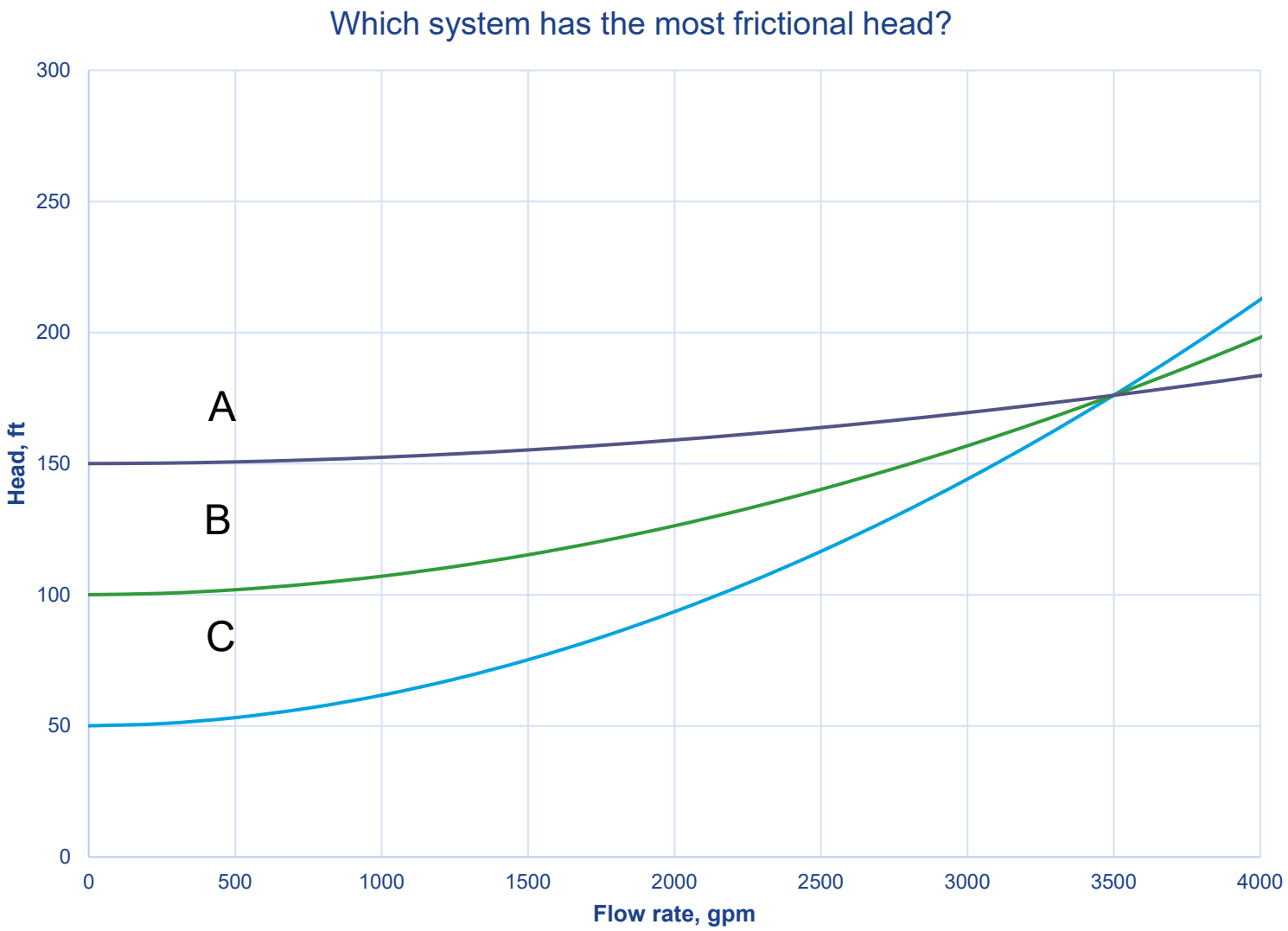
- New systems
  - Design calculations and/or hydraulic models
- Existing systems
  - Hydraulic models (lots of time and tolerance are handy assets for this)
  - Field measurements and basic layout information



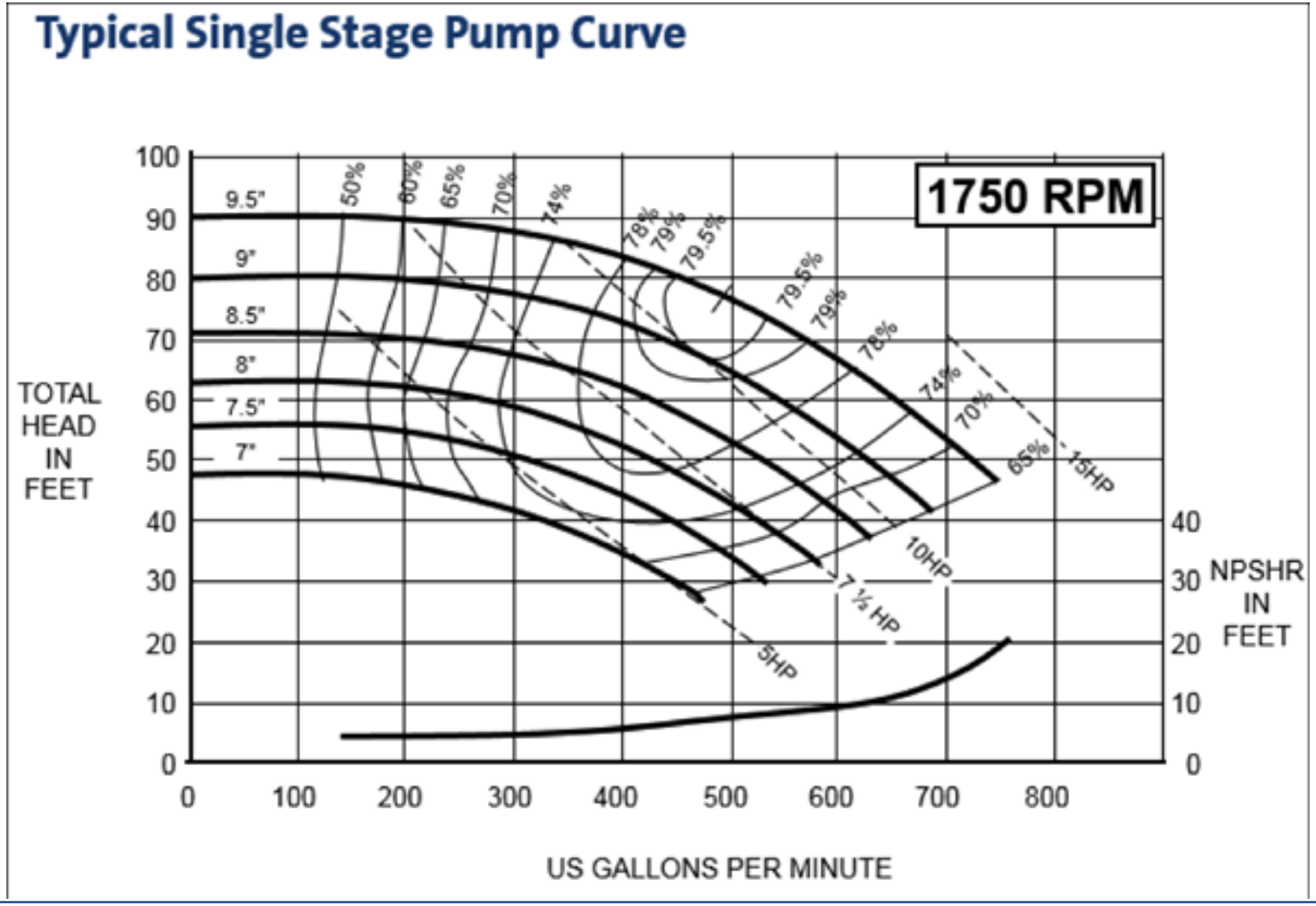
NOTES:

1. If anything in the system changes – including valve positions, flow paths, tank levels, etc., the system curve will change.
2. For systems with multiple suction sources and/or discharge receivers that have different amounts of static head, the system curve will have a more complex characteristic.

Poll question



Pump performance characteristics



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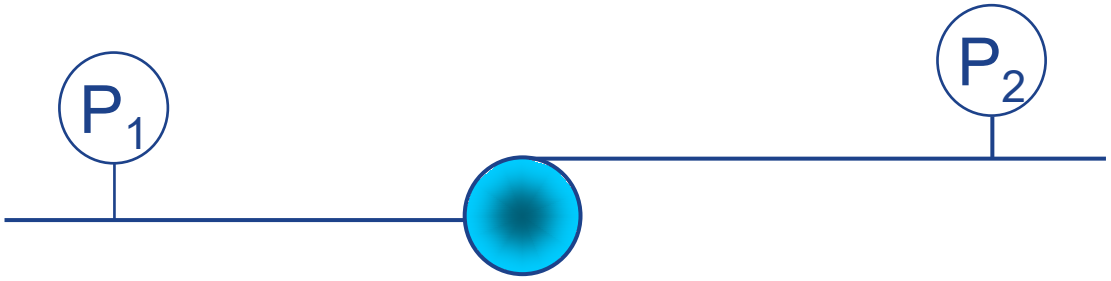
There are four types of performance curves that are used to characterize pumps

- Head
- Shaft power
- Efficiency
- Net positive suction head required (NPSHR)

The Bernoulli relationship is slightly modified to define the pump head



$$\frac{V_1^2}{2g} + \frac{2.31\ P_1}{s.g.} + Z_1 + \mathrm{H_{pump}} = \frac{V_2^2}{2g} + \frac{2.31\ P_2}{s.g.} + Z_2$$

or

$$\mathrm{H_{pump}} = \left(\frac{V_2^2}{2g} + \frac{2.31\ P_2}{s.g.} + Z_2\right) - \left(\frac{V_1^2}{2g} + \frac{2.31\ P_1}{s.g.} + Z_1\right)$$

H_{pump} = Pump head at a given flow rate

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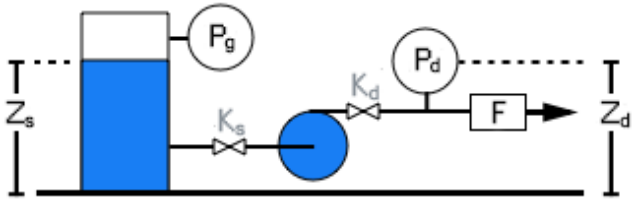
MEASUR Pump Head Calculator

PUMP HEAD TOOL

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	1.002	
Flow Rate	3000	gpm

Suction			Discharge		
Pipe diameter (ID)	12	in	Pipe diameter (ID)	12	in
Tank gas overpressure (P_g)	0	psi	Gauge pressure (P_d)	124	psi
Tank fluid surface elevation (Z_s)	10	ft	Gauge elevation (Z_d)	10	ft
Line loss coefficients (K_s)	0.5		Line loss coefficients (K_d)	1	

Generate Example | Reset Data

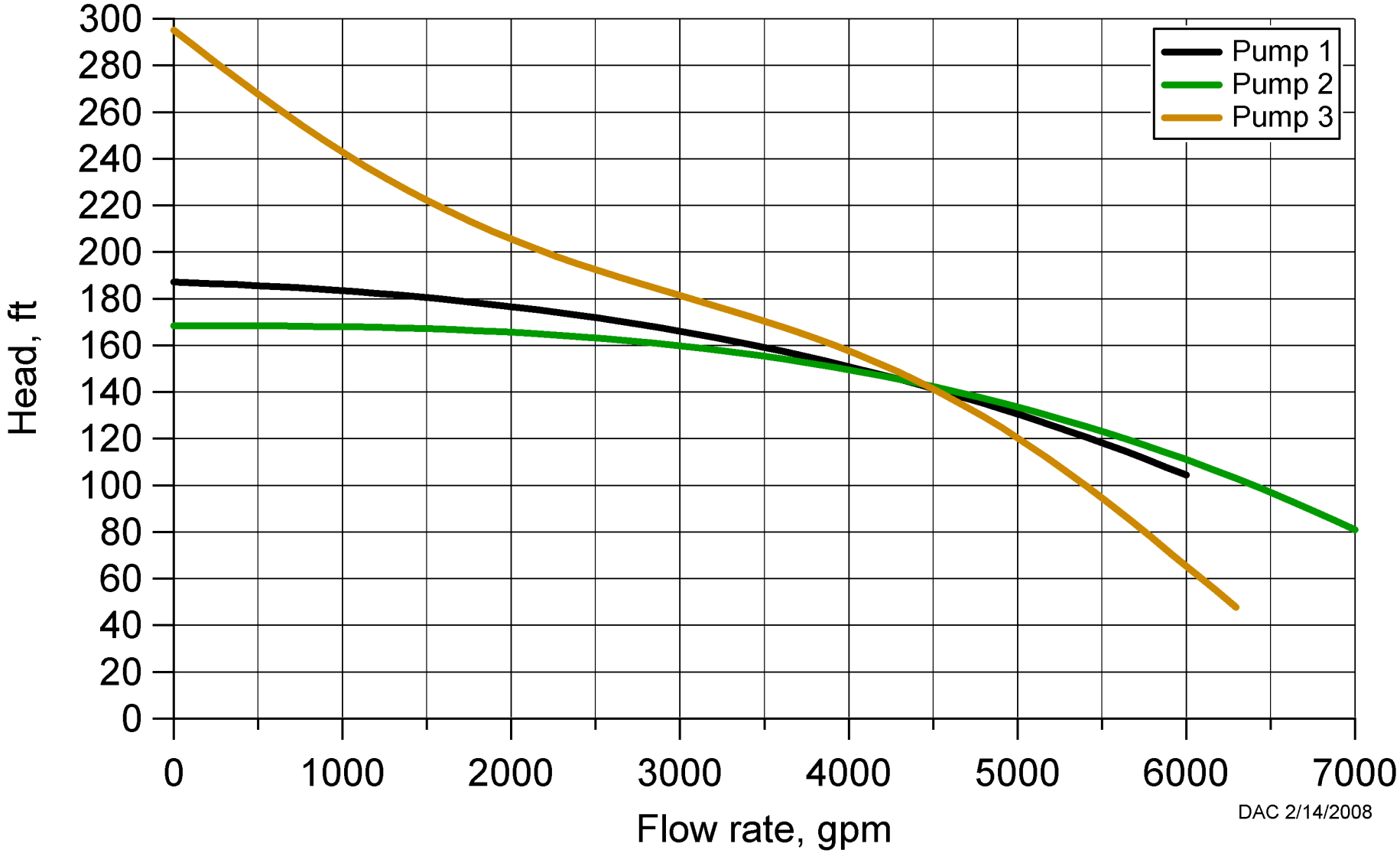
MEASUR Pump Head Calculator Results

RESULTS | HELP

Result Data

Differential Elevation Head	0.0 ft
Differential Pressure Head	285.97 ft
Differential Velocity Head	1.13 ft
Estimated Suction Friction Head	0.56 ft
Discharge Friction Head	1.13 ft
Pump Head	288.78 ft

Pump curve shapes vary: Head curves for three pump designs



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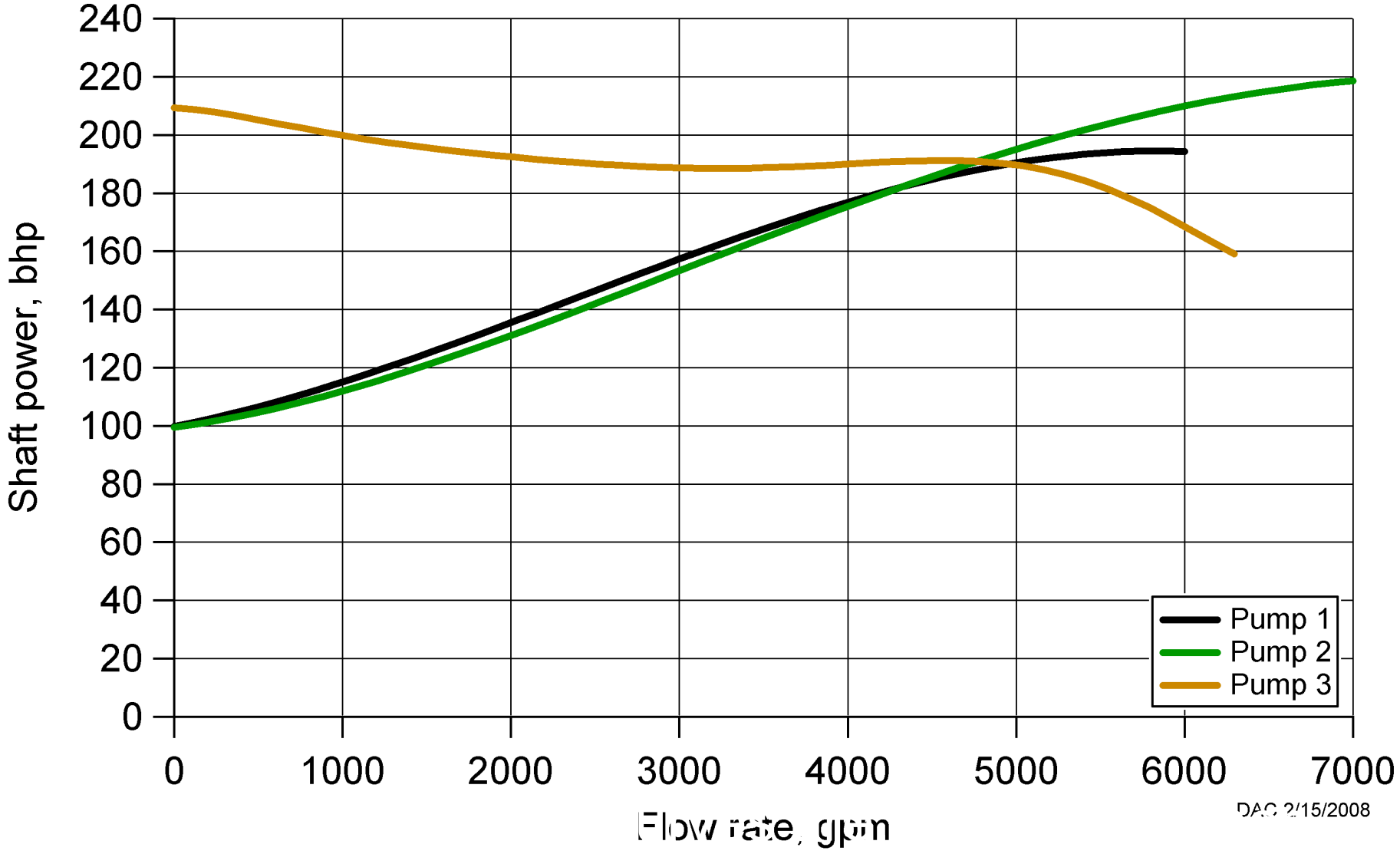
Shaft power curves for the three pumps



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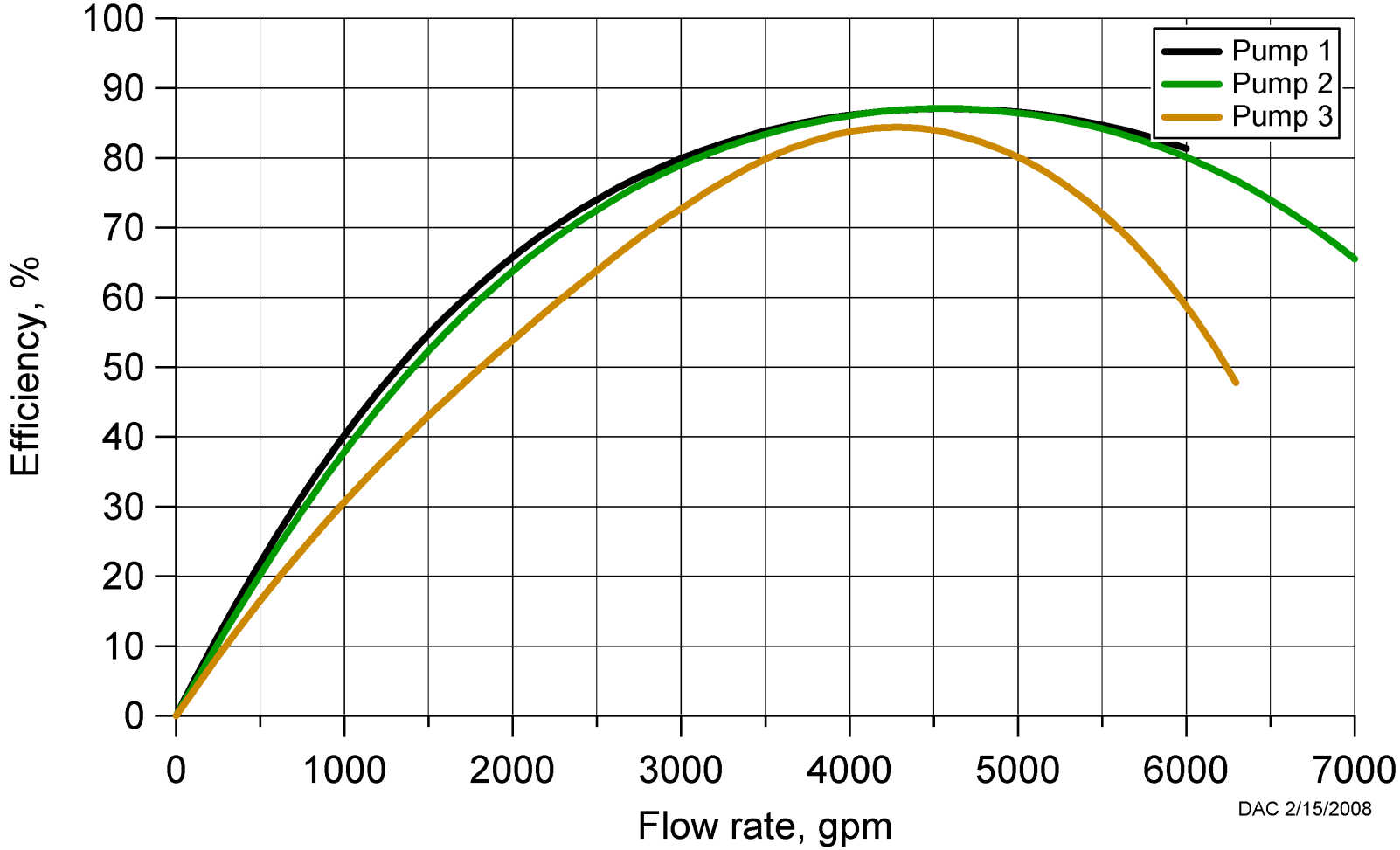
Efficiency curves for the three pumps



Pump efficiency = fluid power output / shaft power input

= gpm x ft x s.g. / (39.60 x shaft hp) for efficiency expressed in %

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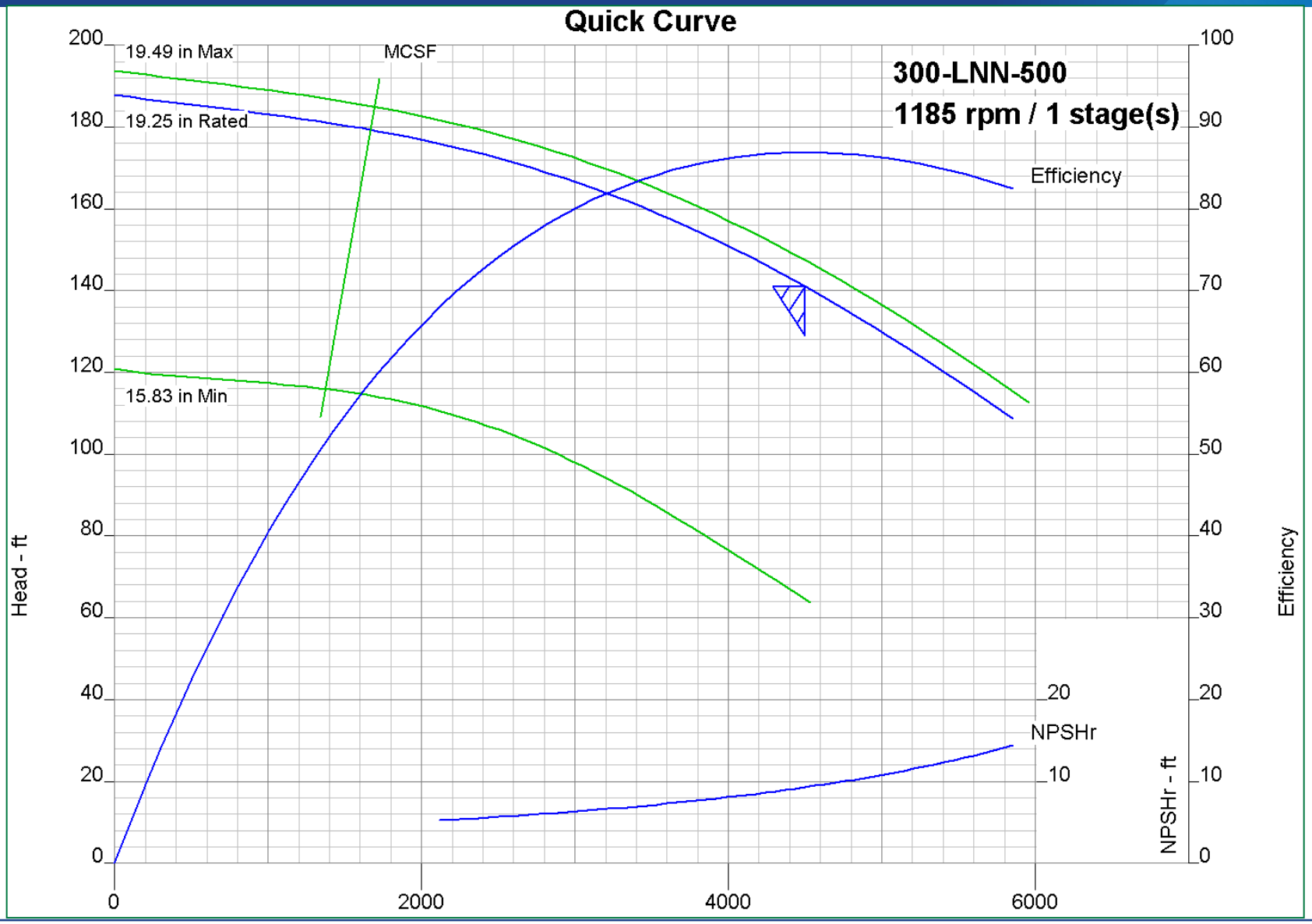
Pump manufacturers provide performance curves in a variety of ways (Following examples are from pump mfr. performance curve software programs or electronic curves)

References:

1. Flowserve Pros+ SE, v 3.3.1, www.flowserve.com
2. Goulds Pump Selection System, www.gouldspumps.com/pss.html
3. Grundfos WinCAPS, v. 7.80.16, www.grundfos.com/web/homeus.nsf
4. Floway, www.weirclearliquid.com/
5. Flygt FLYPS, v. 3.1, http://www.flygt.com/

Pump 1 line curves plus min/max impeller size head curves



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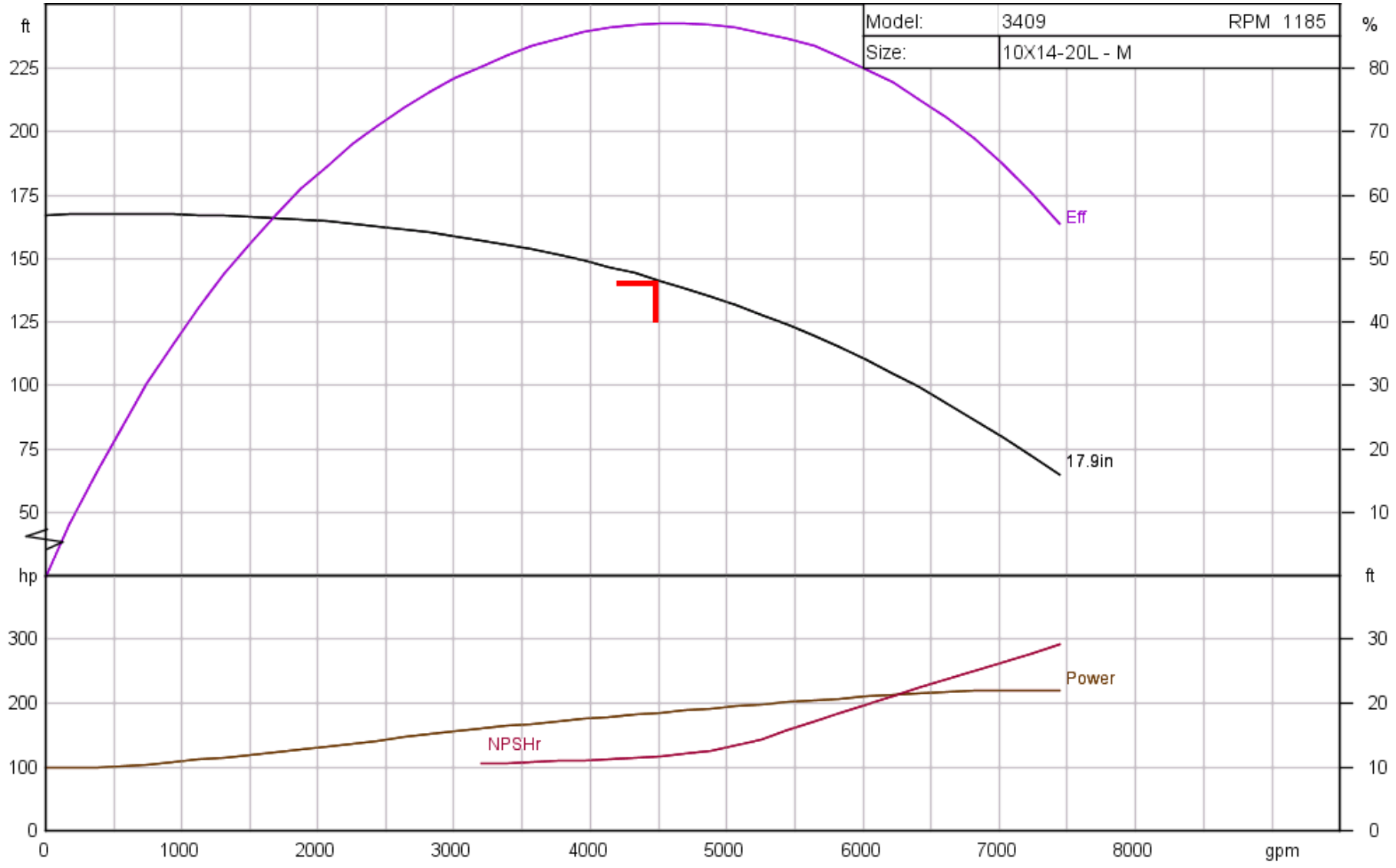
Pump 2 line curves for head, efficiency, shaft power, NPSHR



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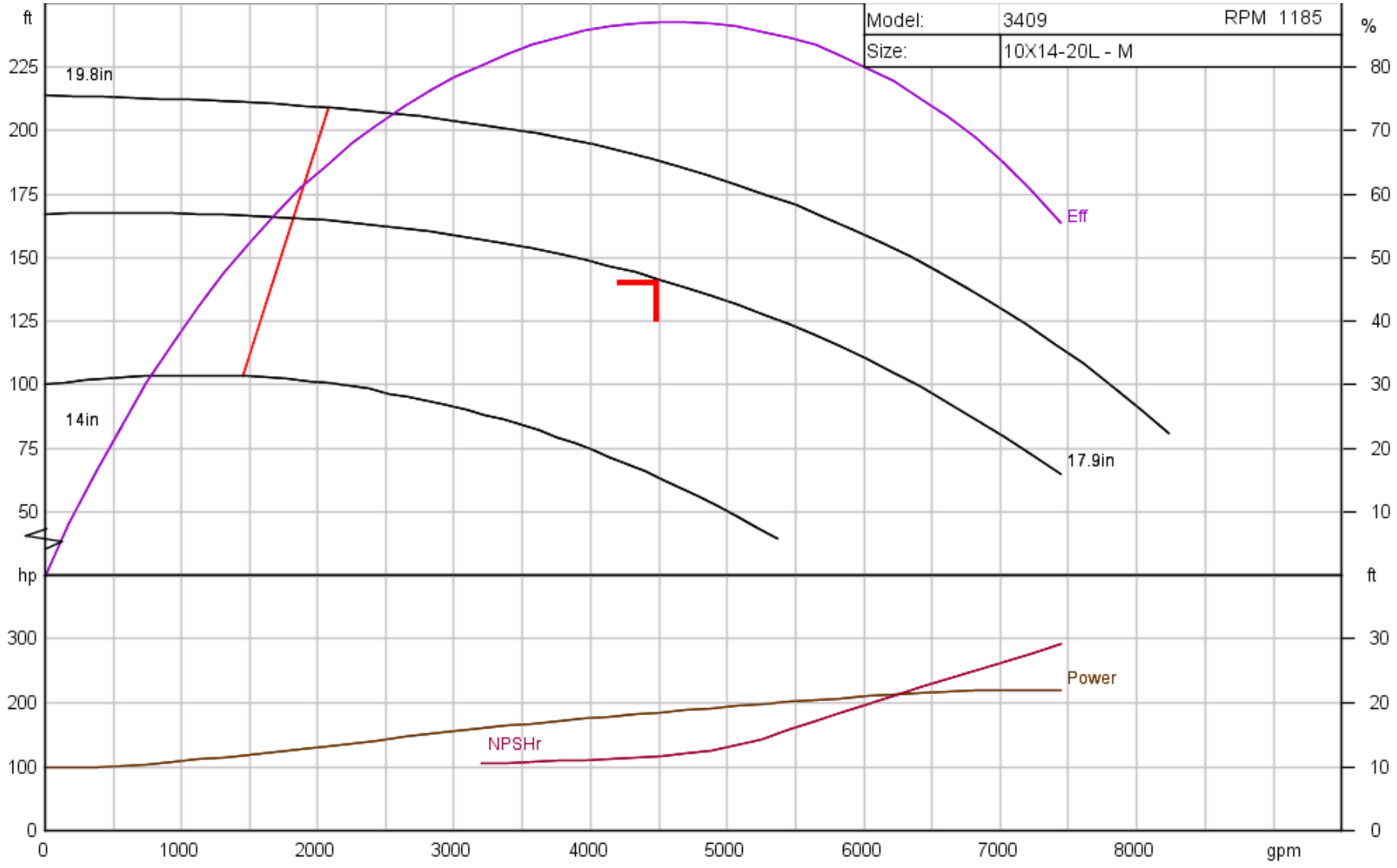
Pump 2 line curves + head curve for max/min impeller diameters



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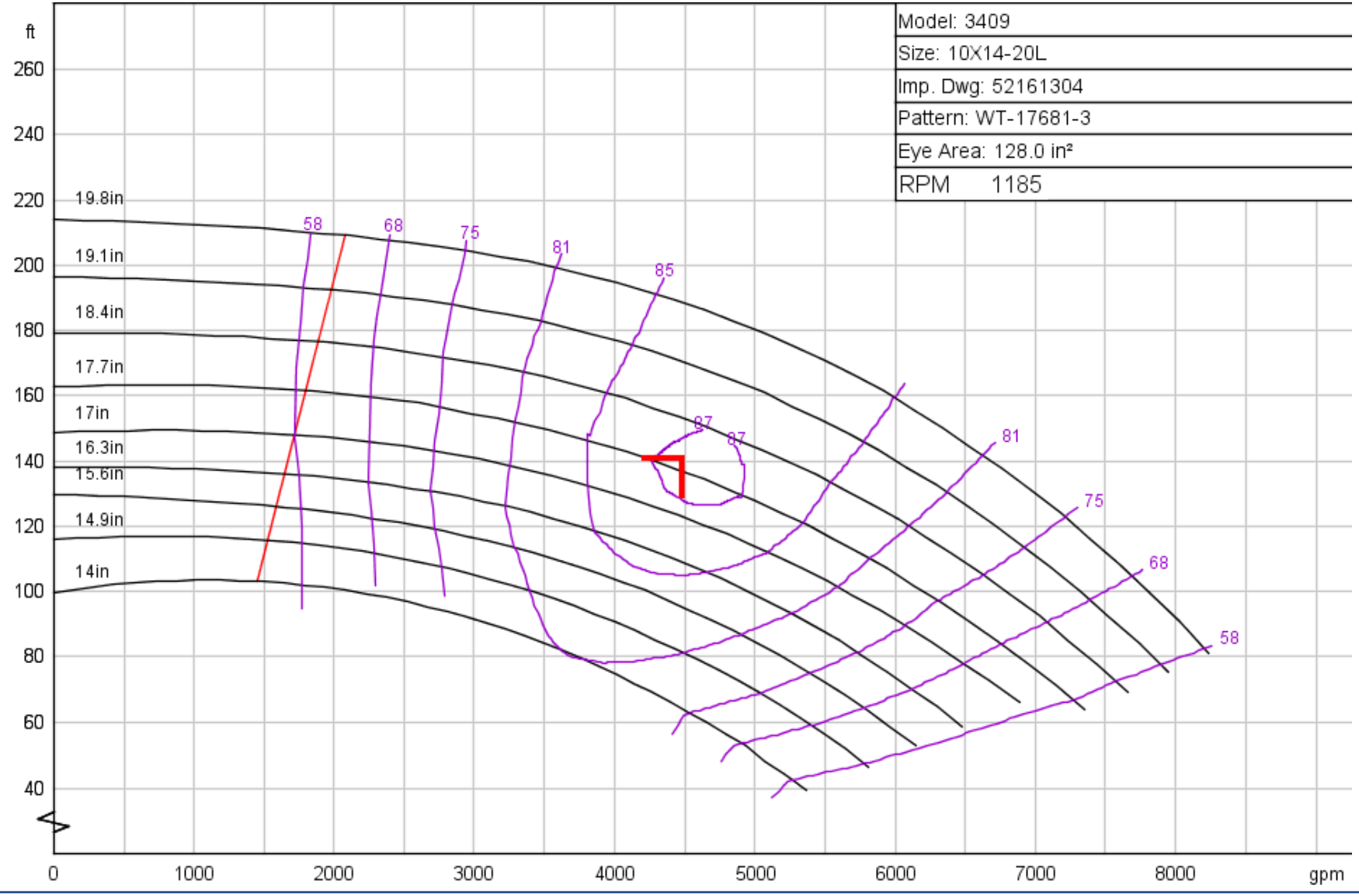
Pump 2 range of impeller sizes, isoefficiency lines



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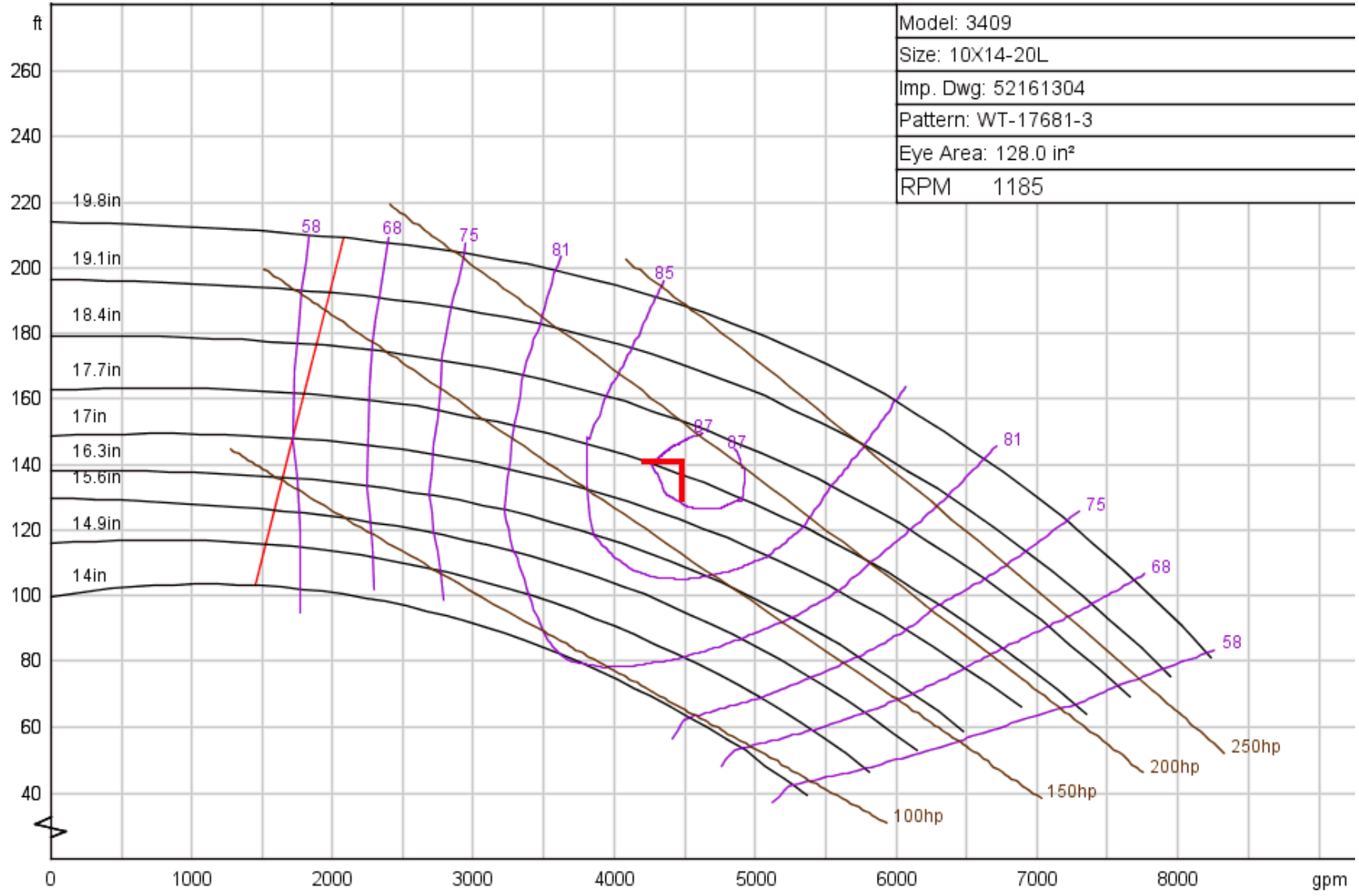
Same as previous slide + shaft power curves



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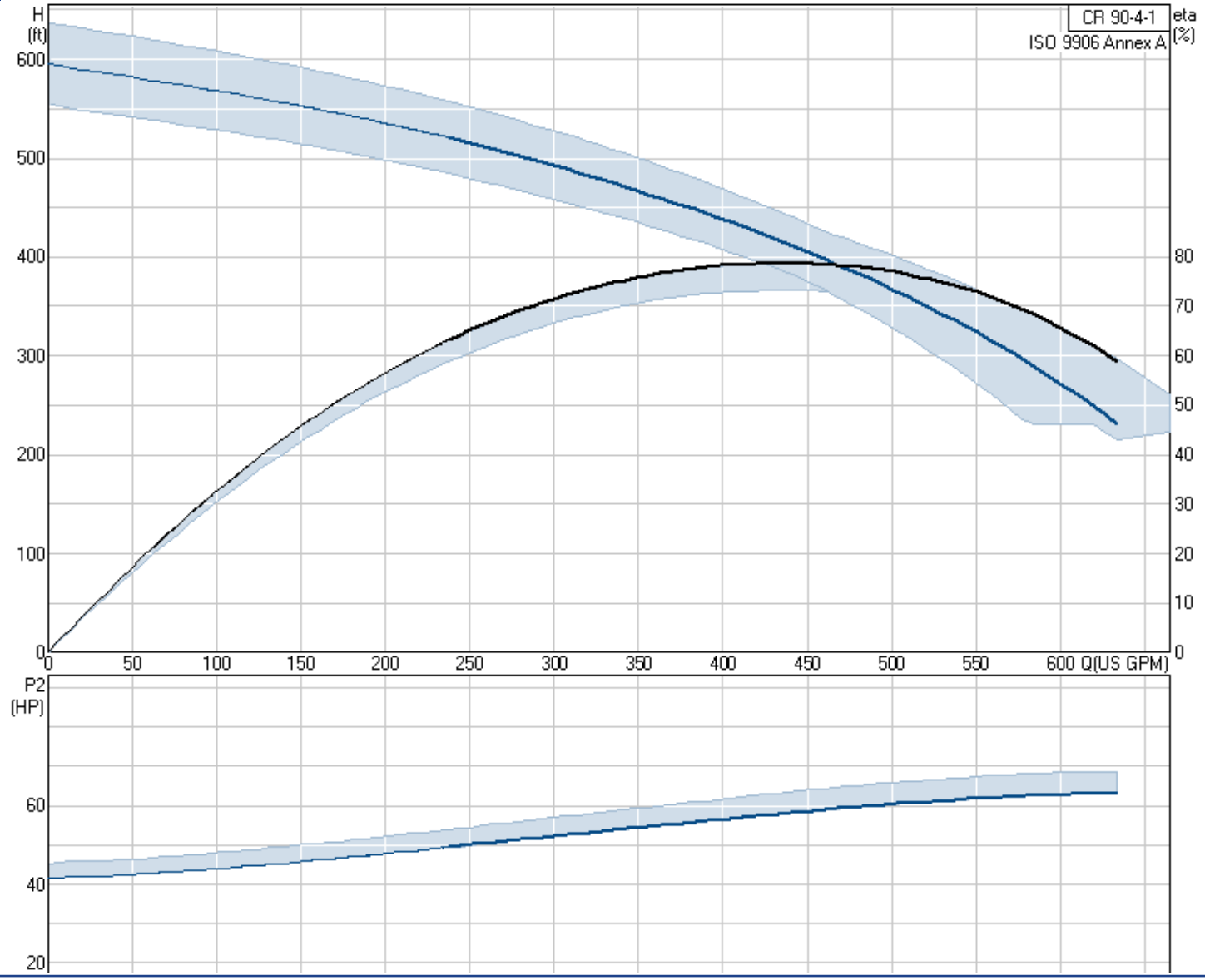
Curves with ISO tolerance bands



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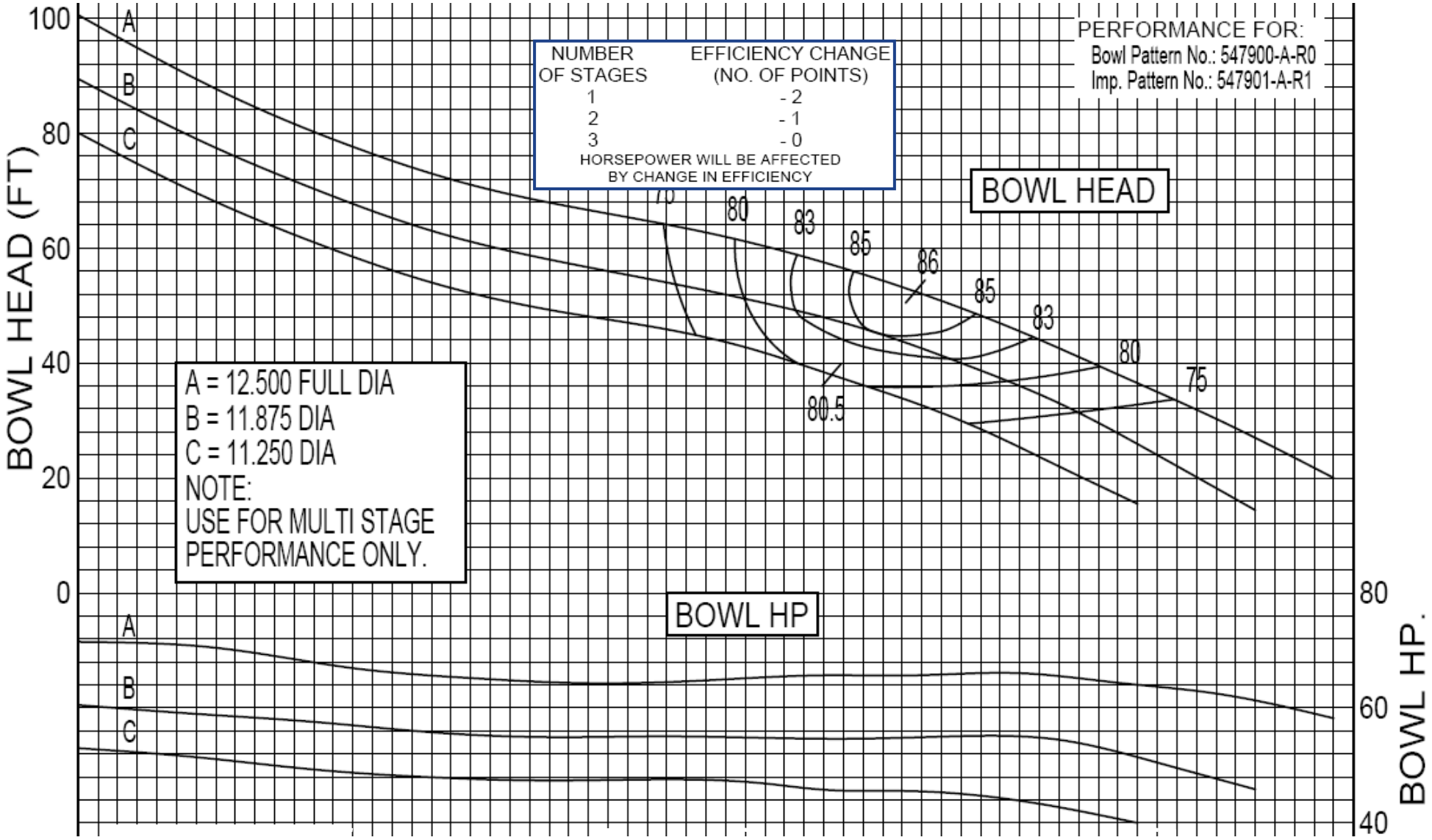
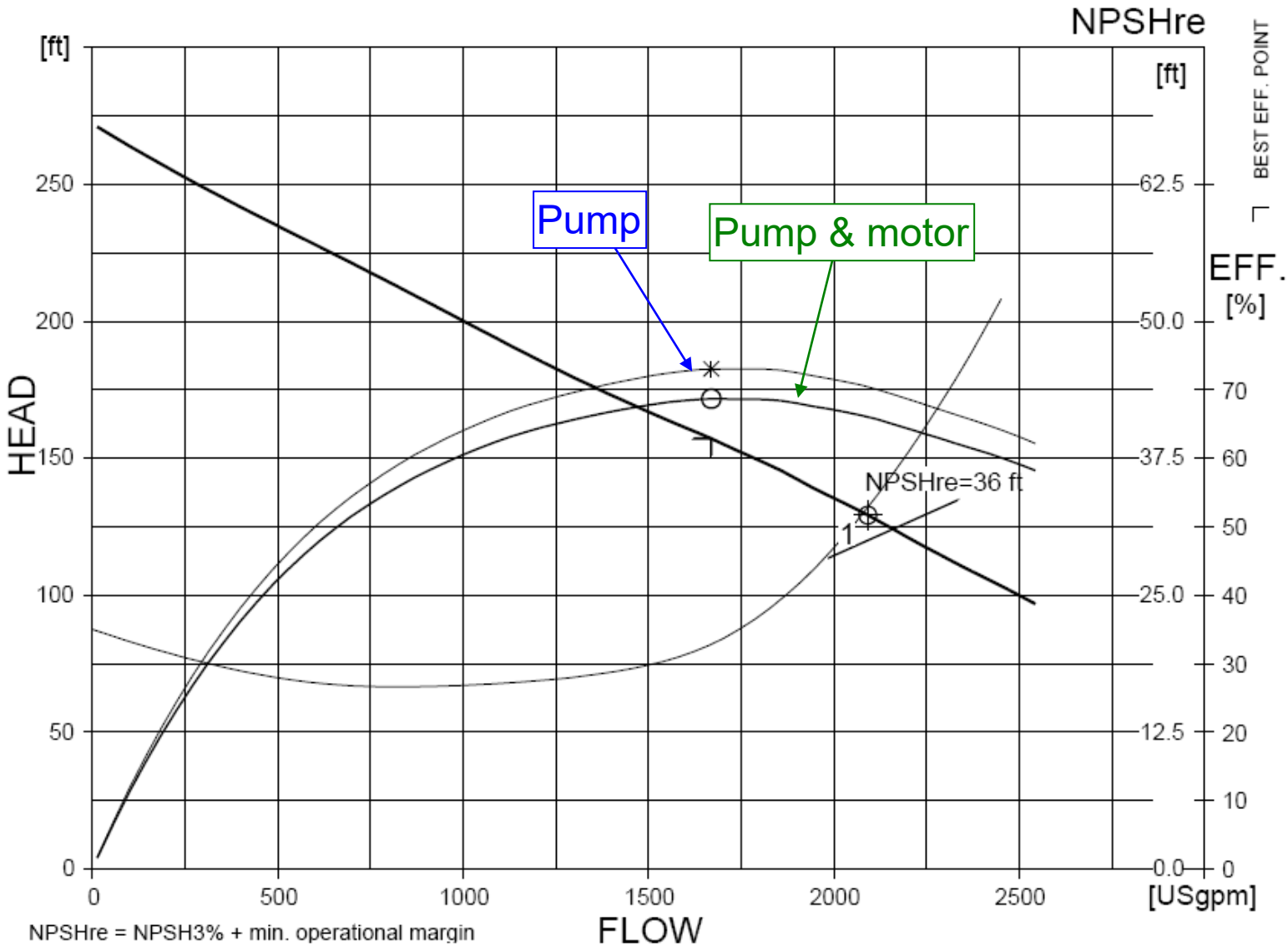
Vertical turbine pump catalog curves are commonly provided in individual stage (bowl) performance format



Vertical Turbine Pump

Vertical turbine pumps are commonly used in all types of applications, from moving process water in industrial plants to providing flow for cooling towers at power plants, from pumping raw water for irrigation, to boosting water pressure in municipal pumping systems, and for many other pumping applications.

Submersible pump and combined pump & motor (sometimes called wire-to-water) efficiency curves



NPSHre = NPSH3% + min. operational margin
Performance with clear water and ambient temp 40 °C

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Break

Pump affinity laws and parallel or series pump operation

Pump affinity laws can be used to predict pump curves for different speeds and impeller diameters

Speed

$$\left(\frac{Q_1}{Q_2}\right) = \left(\frac{N_1}{N_2}\right)^1$$

$$\left(\frac{H_1}{H_2}\right) = \left(\frac{N_1}{N_2}\right)^2$$

$$\left(\frac{P_1}{P_2}\right) = \left(\frac{N_1}{N_2}\right)^3$$

$$\left(\frac{\eta_1}{\eta_2}\right) = \left(\frac{N_1}{N_2}\right)^0$$

Diameter

$$\left(\frac{Q_1}{Q_2}\right) = \left(\frac{D_1}{D_2}\right)^1$$

$$\left(\frac{H_1}{H_2}\right) = \left(\frac{D_1}{D_2}\right)^2$$

$$\left(\frac{P_1}{P_2}\right) = \left(\frac{D_1}{D_2}\right)^3$$

$$\left(\frac{\eta_1}{\eta_2}\right) = \left(\frac{D_1}{D_2}\right)^0$$

Q = flow rate
N = speed
H = head
D = diameter
P = power
η = efficiency

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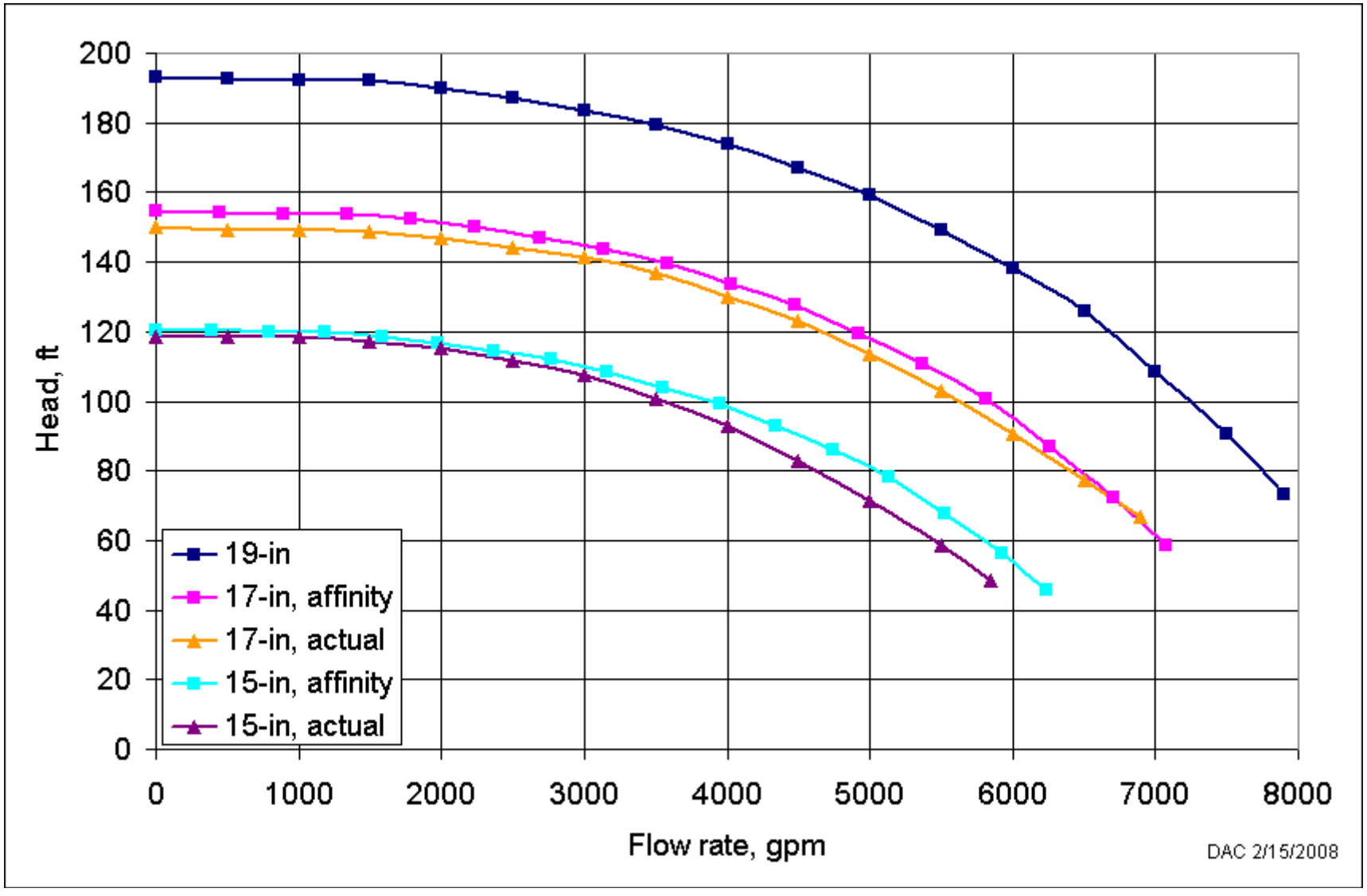
The affinity laws aren't perfect for diameter changes: head curves



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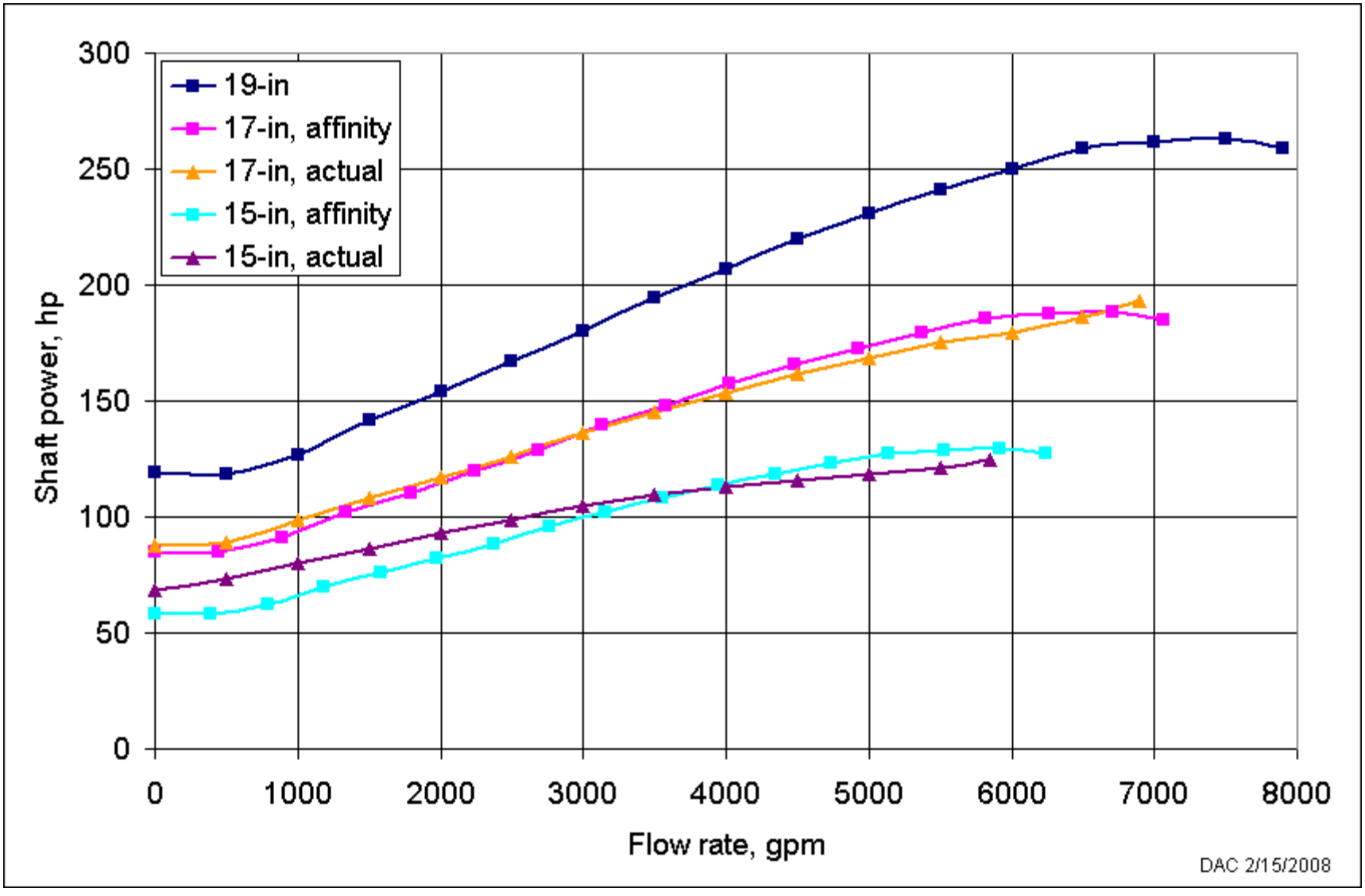
The affinity laws aren't perfect for diameter changes: power curves



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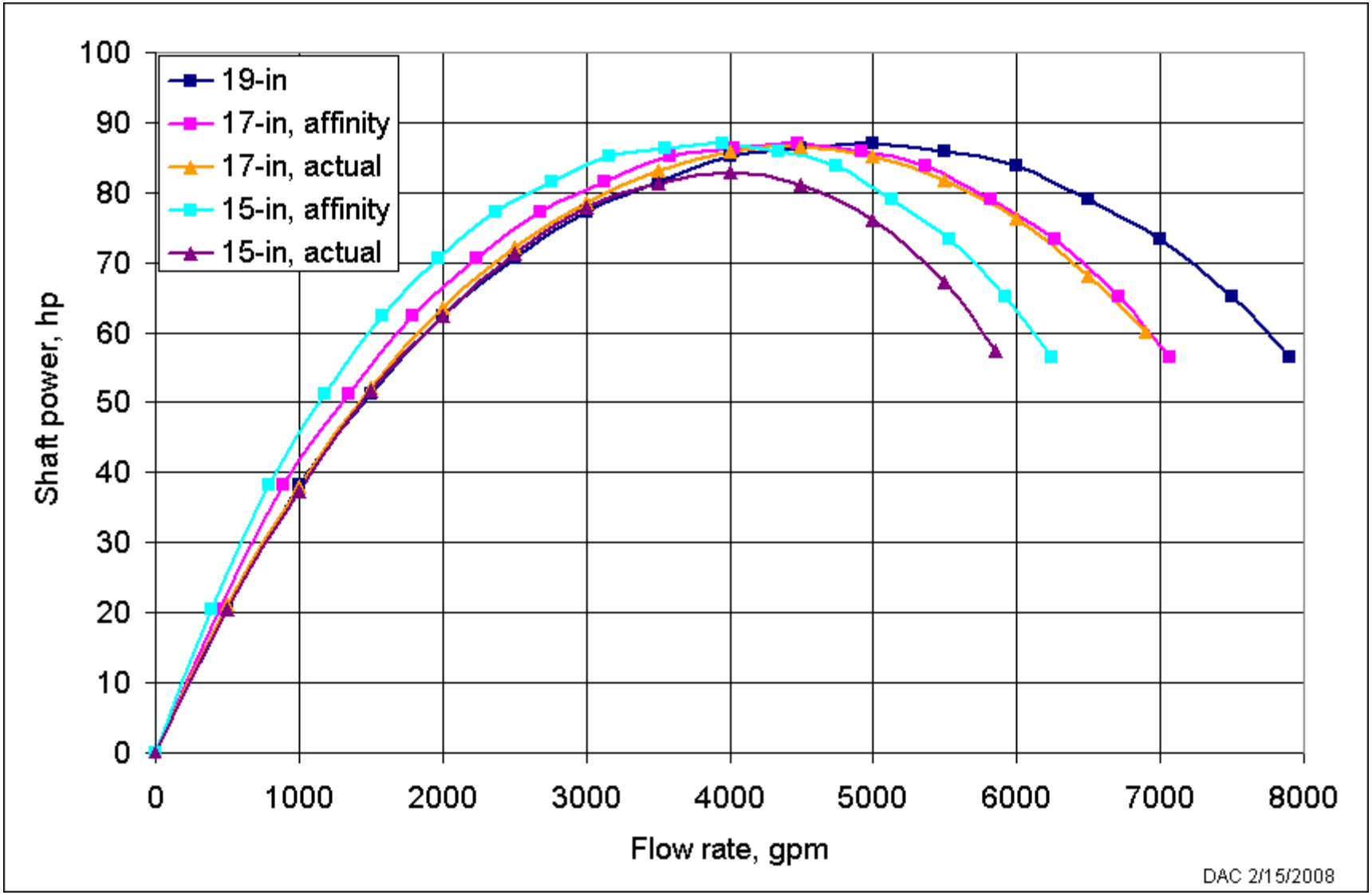
The affinity laws aren't perfect for diameter changes: efficiency curves



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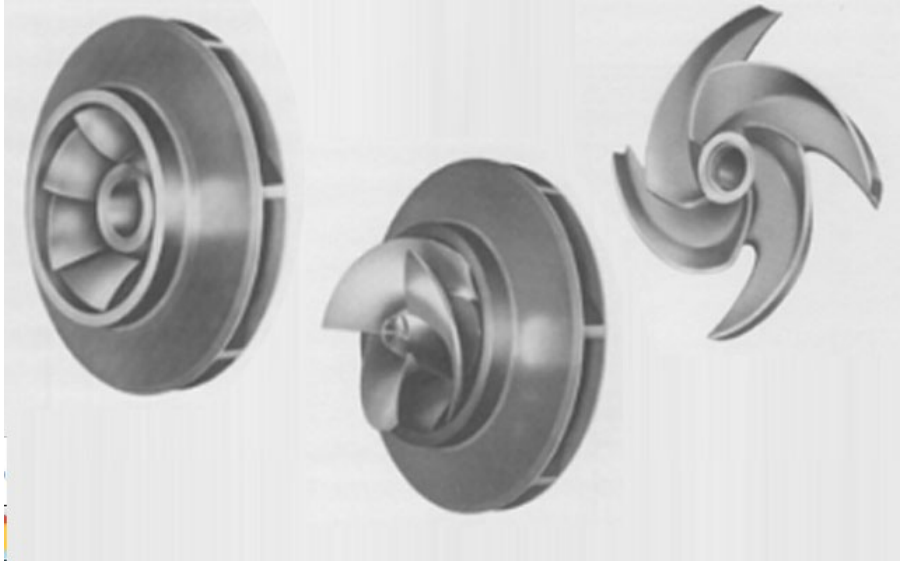
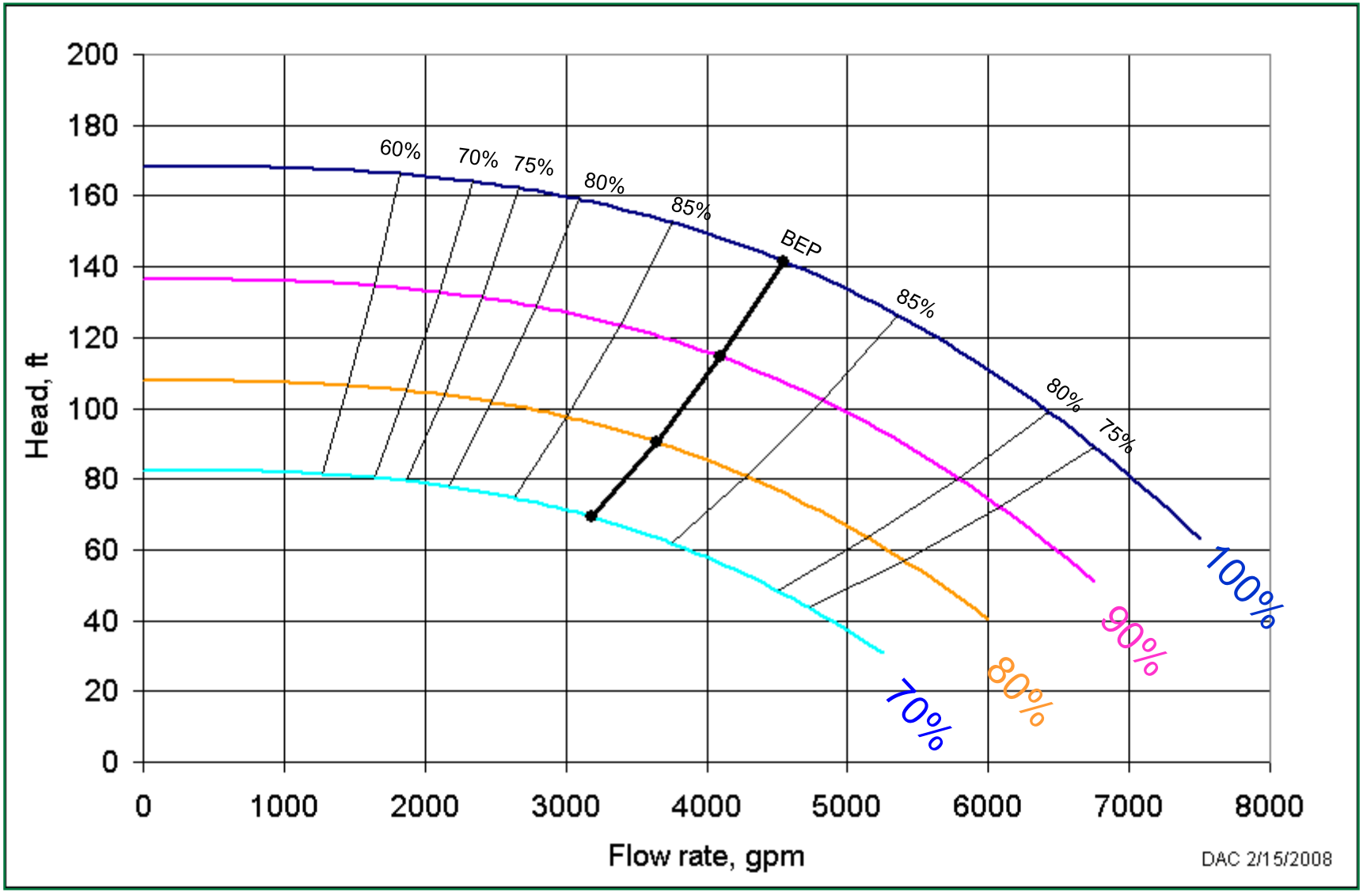
Considering a trim in impeller diameter?

Recommendations:

1. Get actual performance curves from the manufacturer, especially if the trim change being considered is large
2. Do a field performance test of the existing pump



But the affinity laws generally hold up very well with speed changes



Note: same pump as previous slides, impeller size = 17.9 inches

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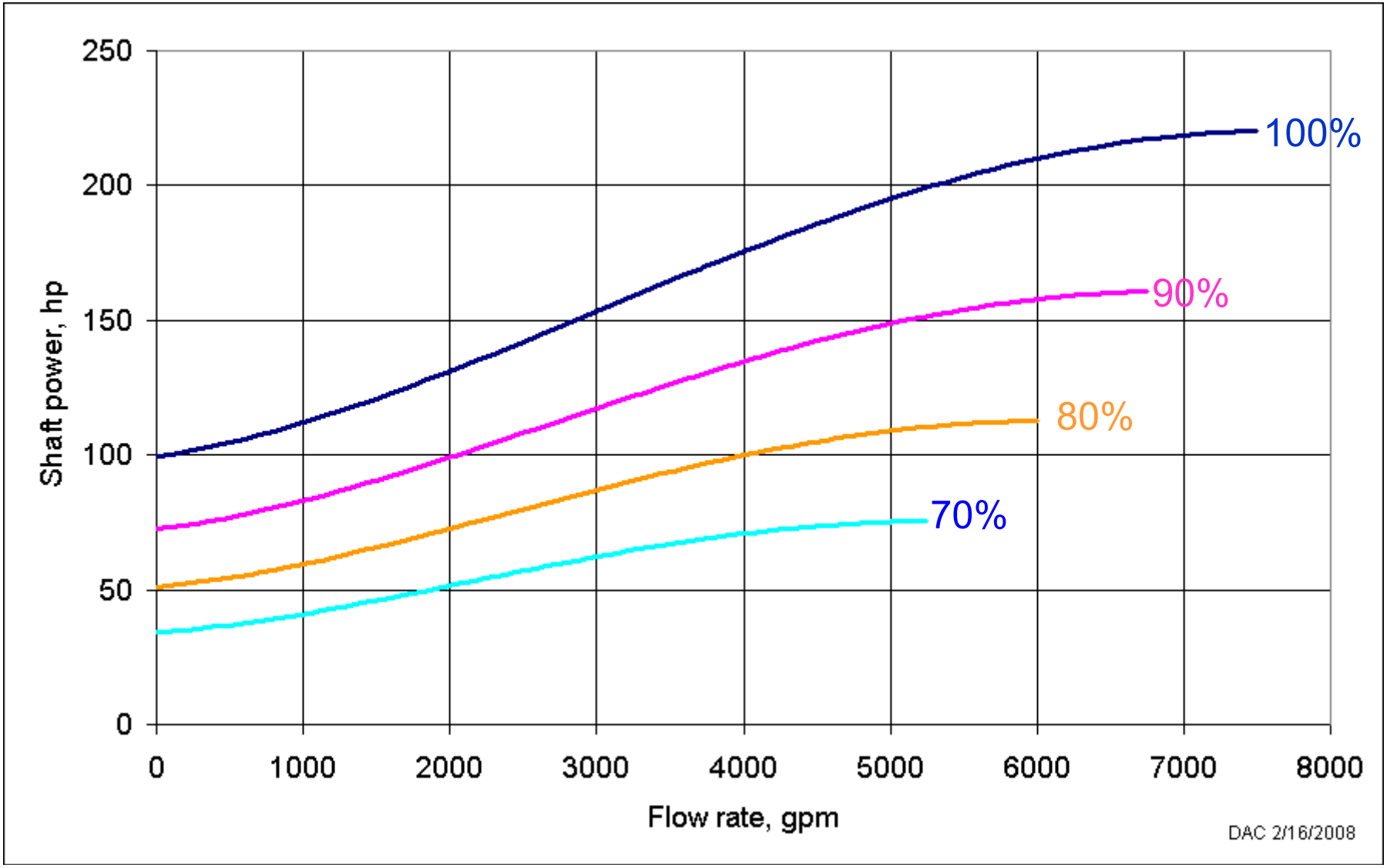
Shaft power curves at four speeds



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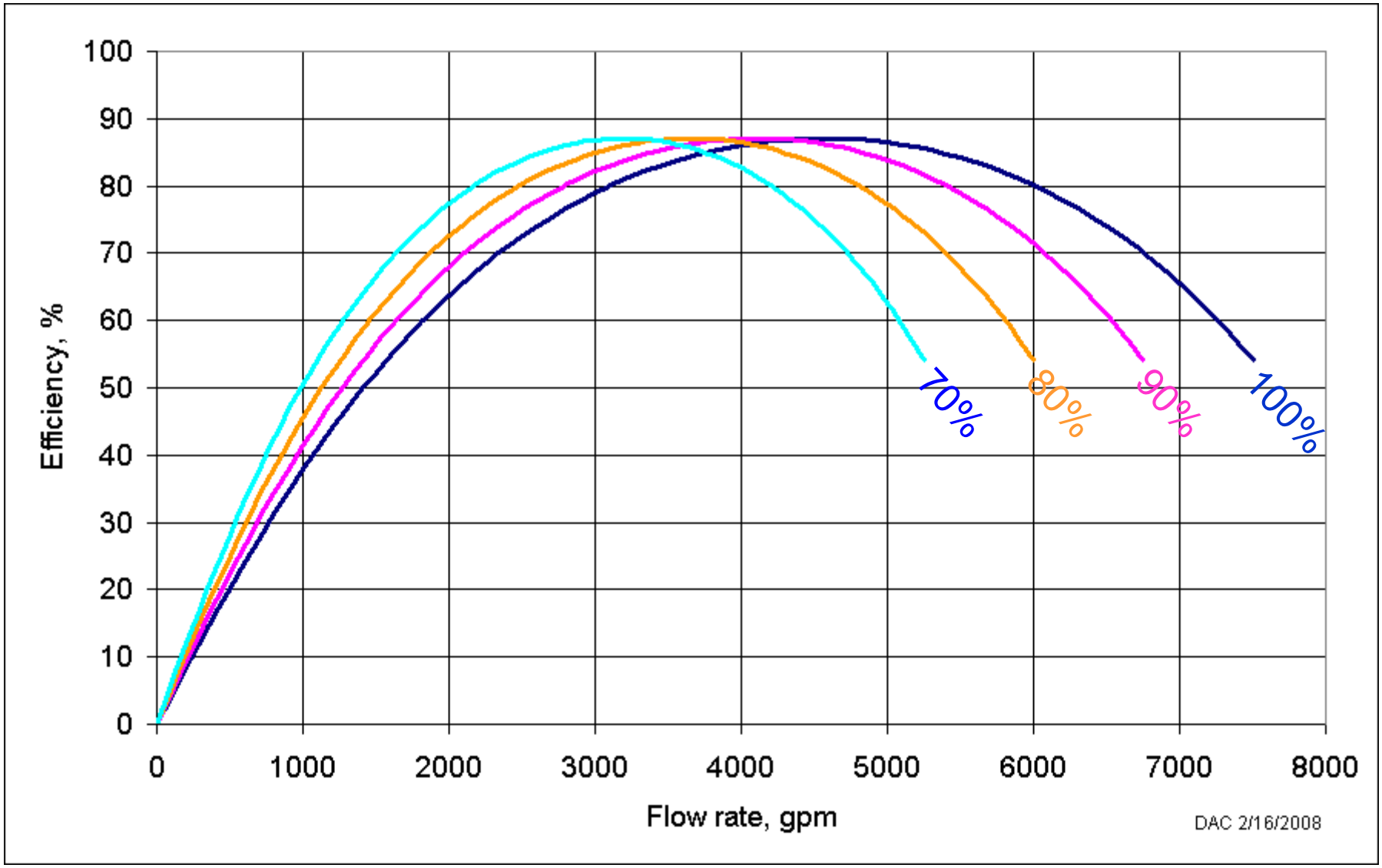
Efficiency curves at four speeds



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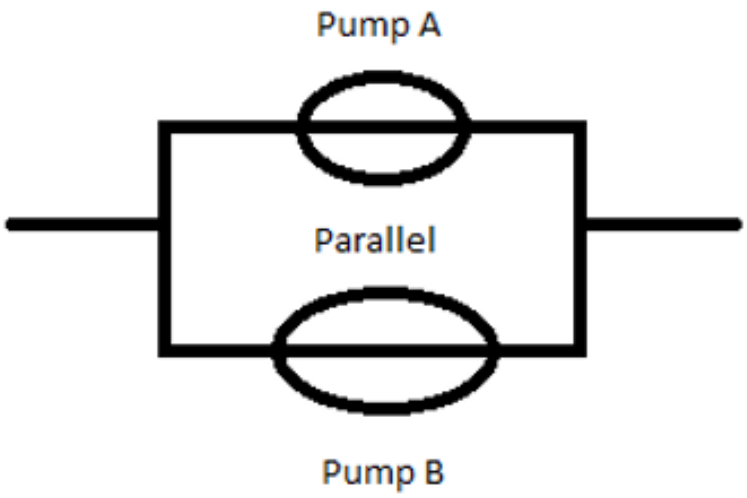
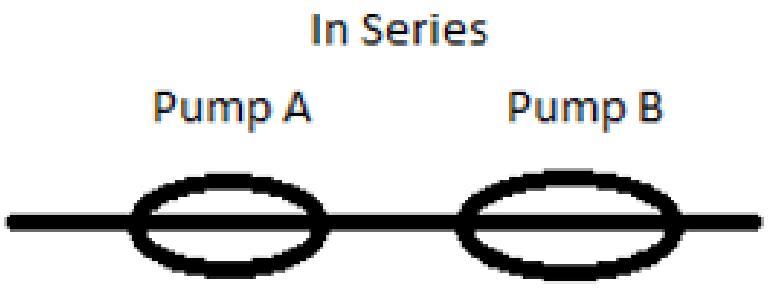
Parallel and series pumping “laws”, like the pump affinity laws apply to the pump curves ***only***

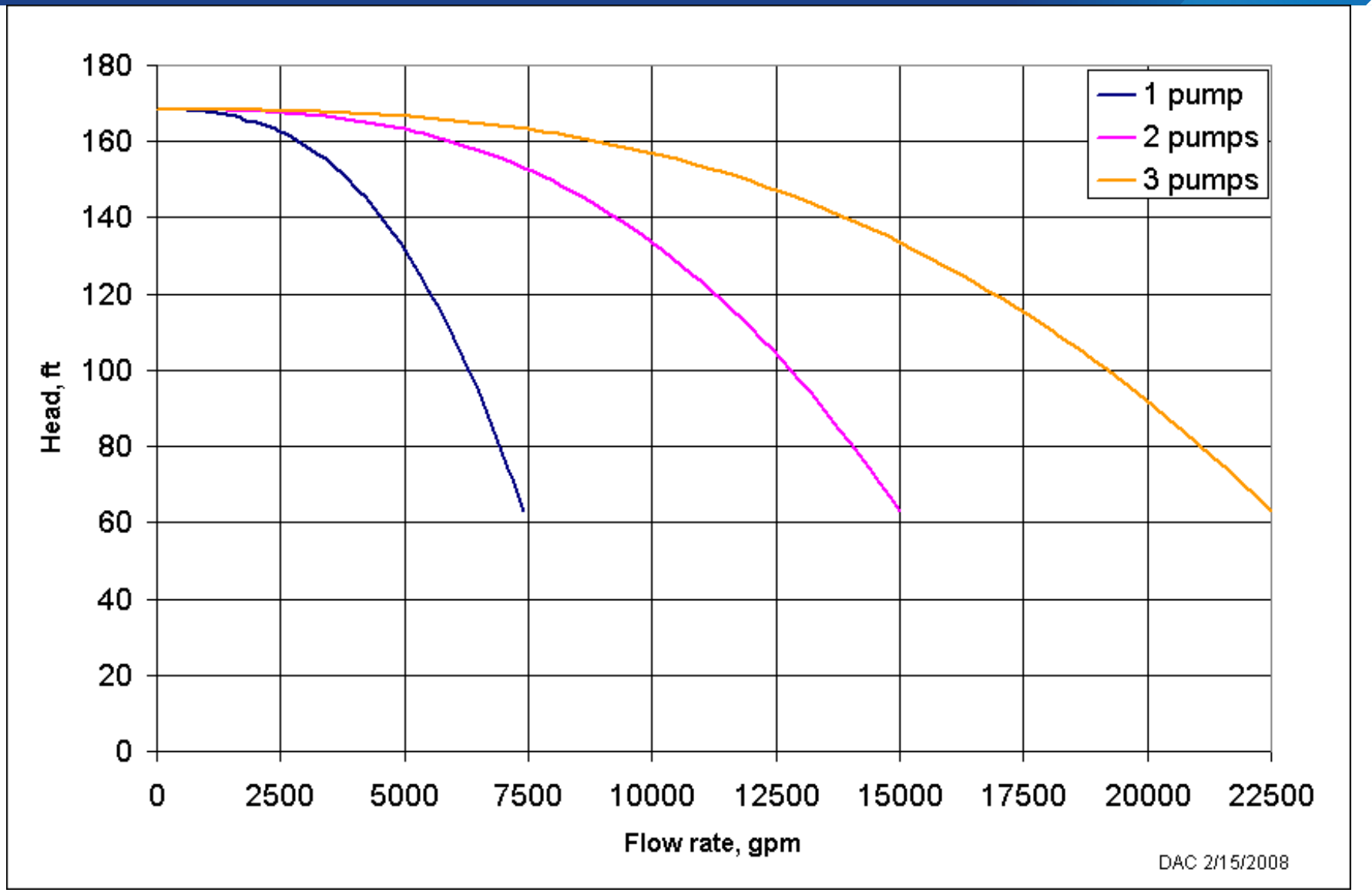
- Parallel pumps - sum the flow rates at a given head

- Series pumps - sum the heads at a given flow rate





Parallel pumps can help adapt to changing system requirements and provide redundancy



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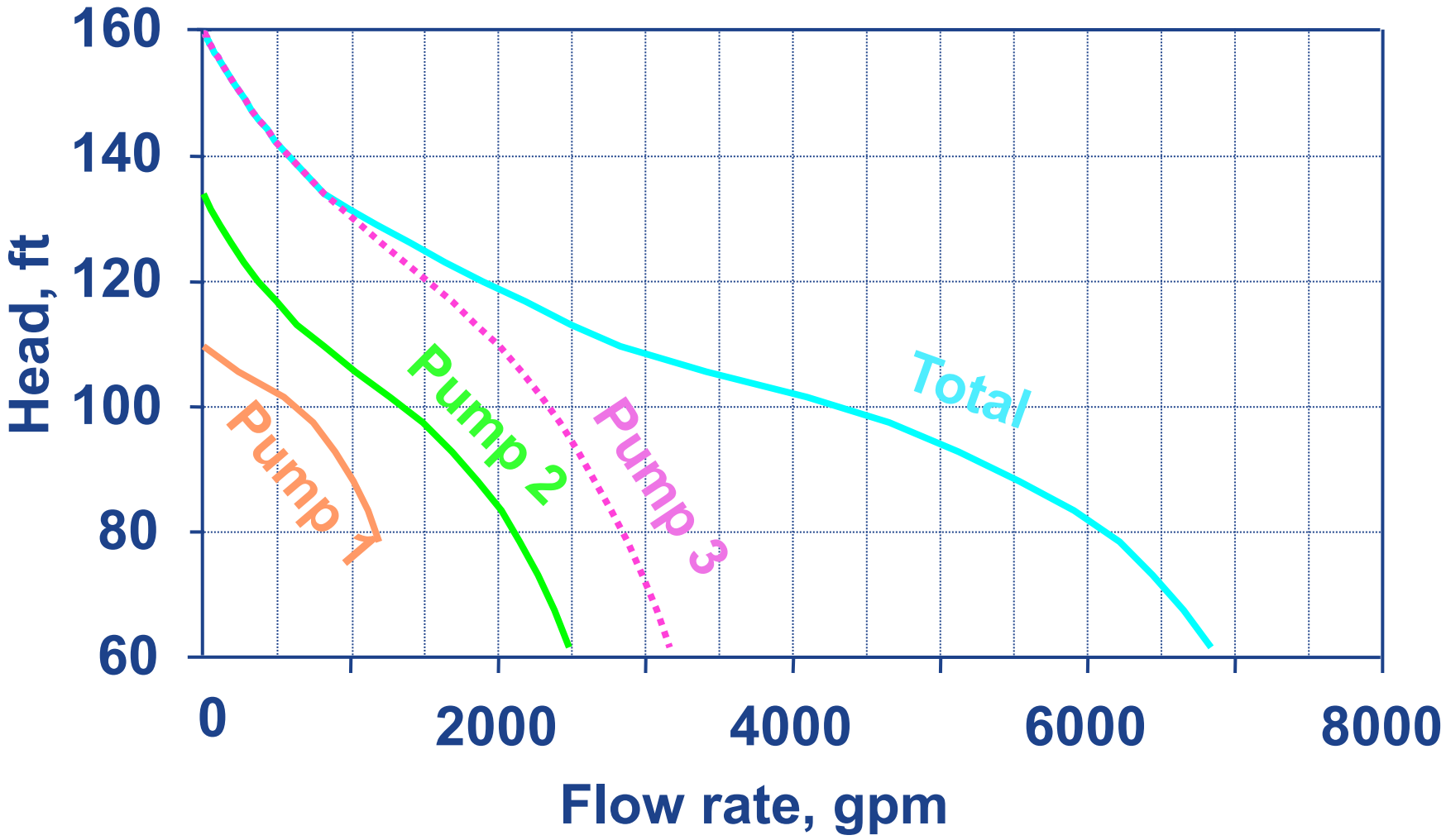
Unlike pumps can also be used in parallel, but with caution



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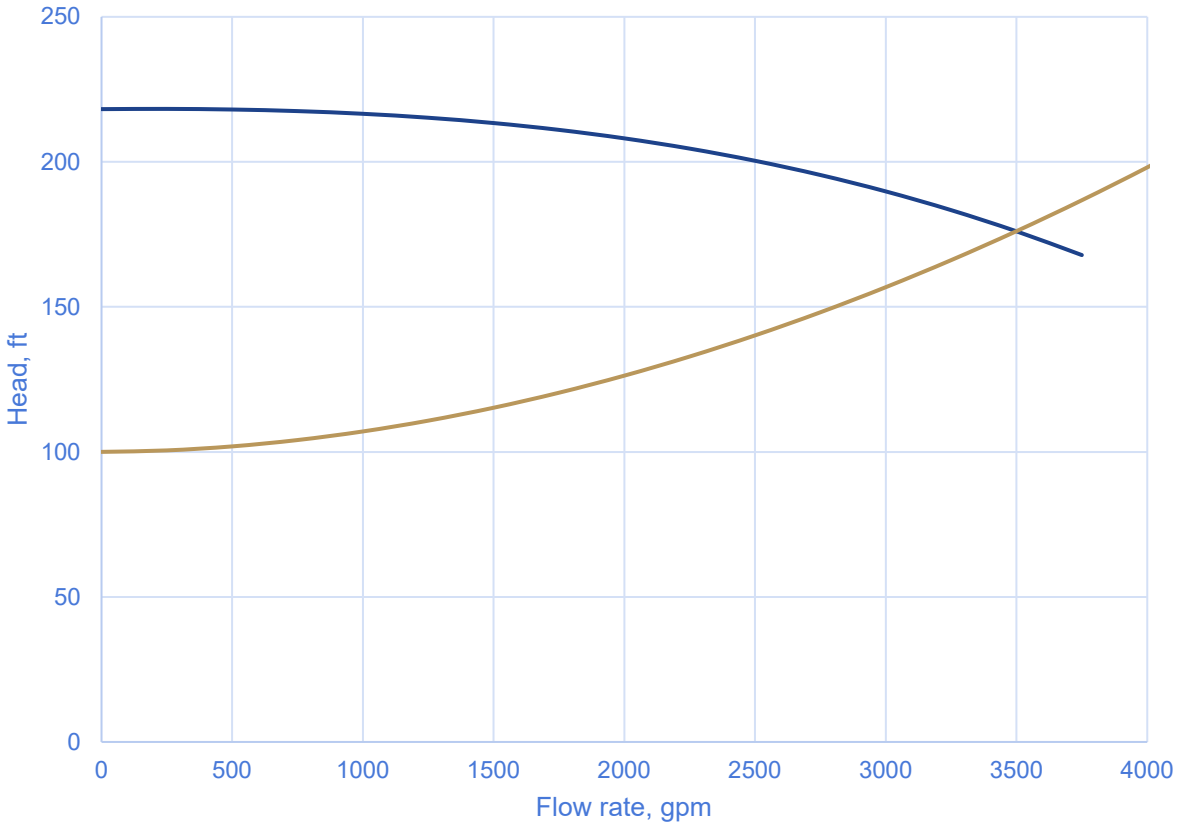
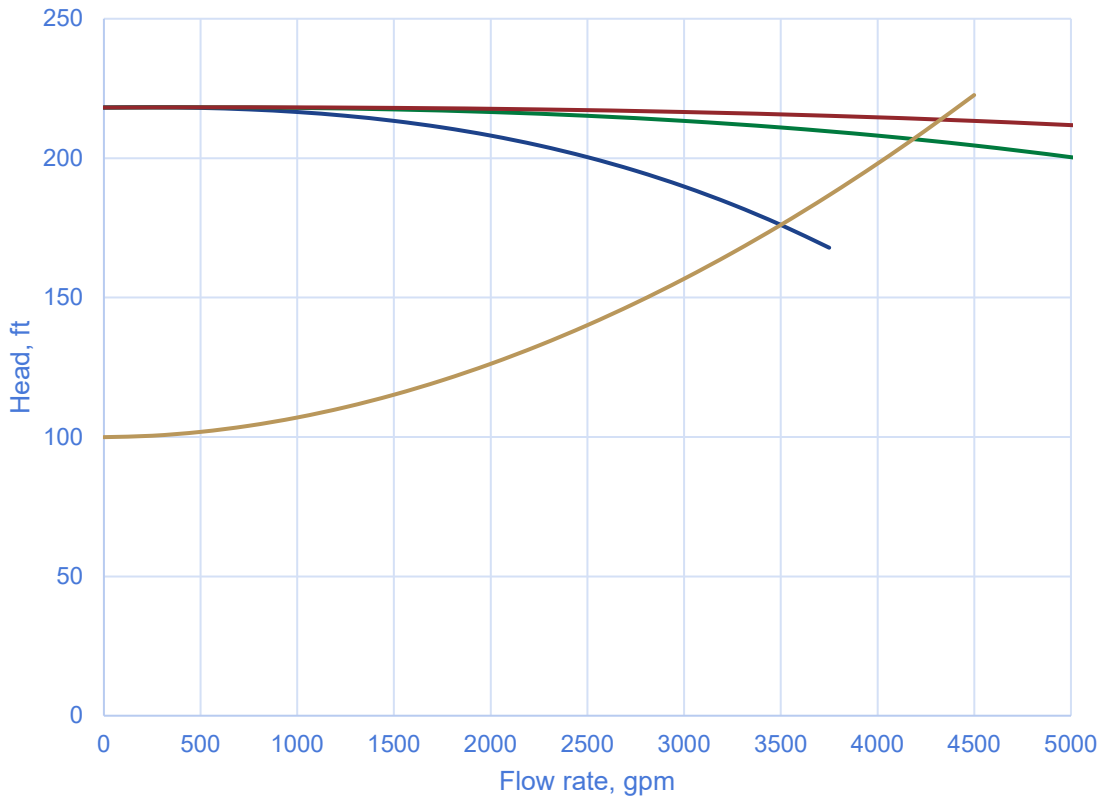
Poll question

What increase in flow would you expect from adding an additional parallel pump?

A. 100%
B. 80%
C. 60%
D. 40%
E. 20%

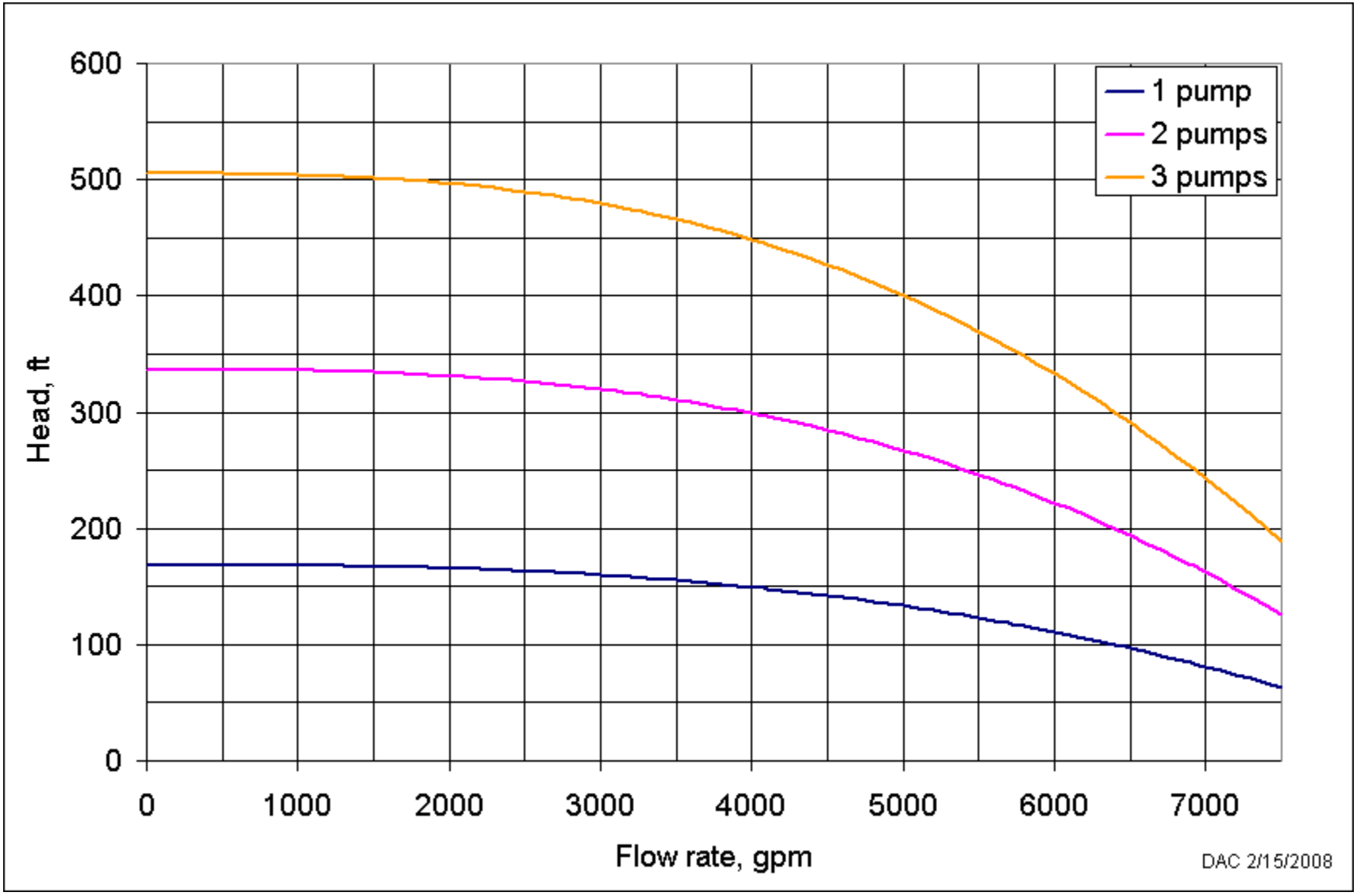


More pumps does not necessarily mean much more flow



Pumps operating	Flow rate, gpm	Head, ft	% increase in flow
1	3500	176.1	0
2	4185	206.8	19.6%
3	4325	213.8	23.6%

Identical pumps in series; add head at a given flow rate to estimate overall performance



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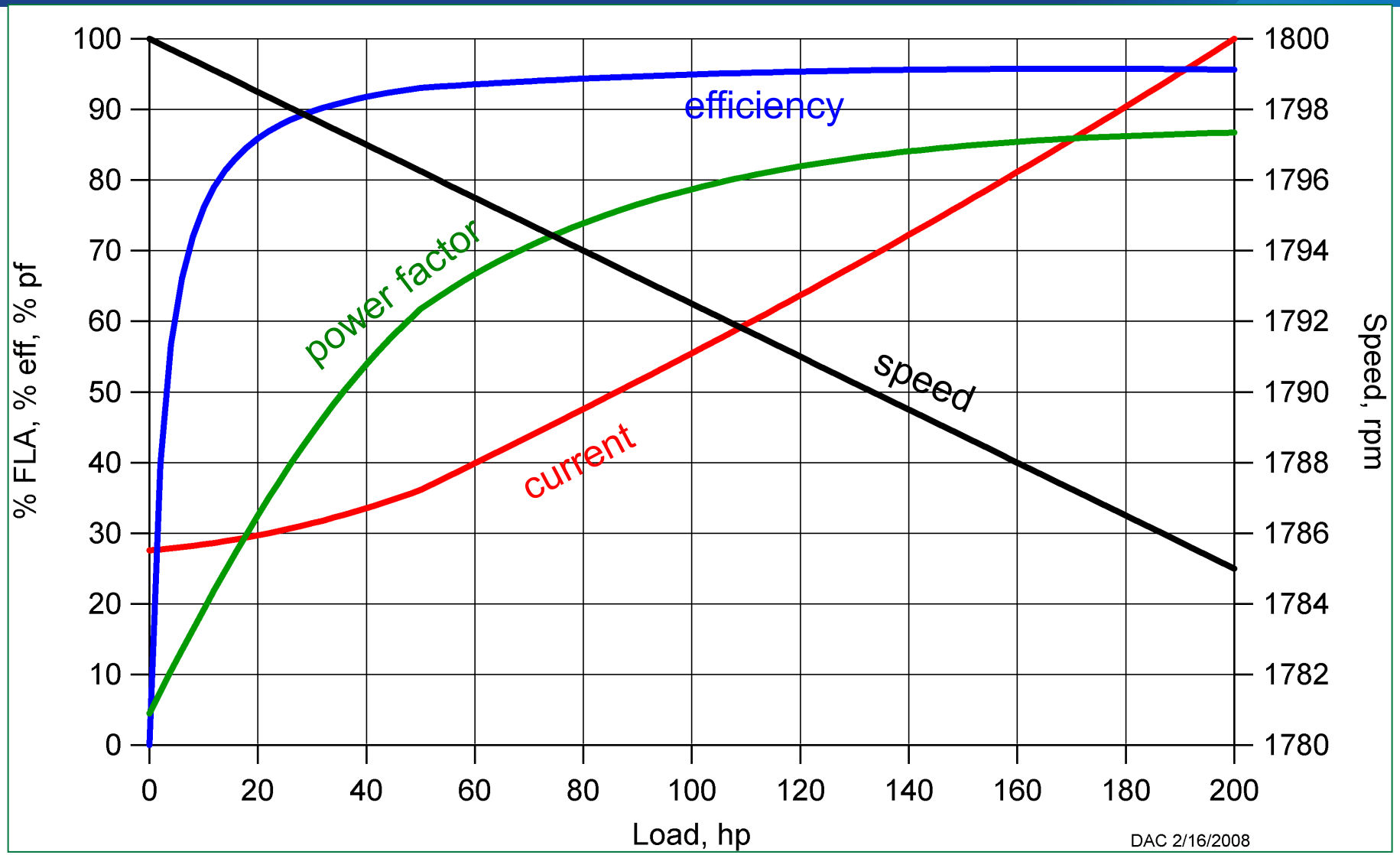
Typical motor performance characteristics (200 hp energy-efficient, 4-pole)



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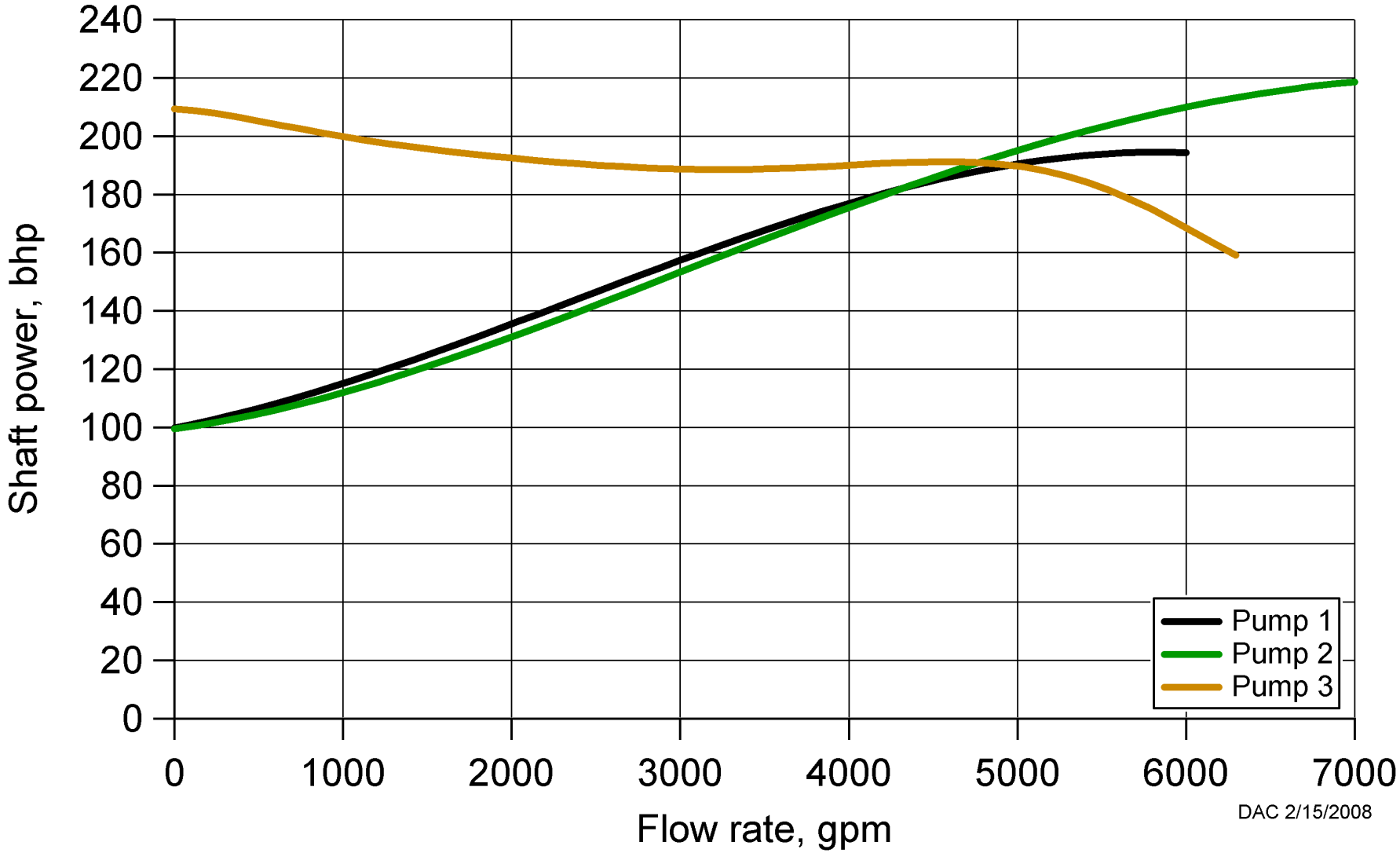
First, let's review what kind of load the pump puts on the motor (at rated speed conditions)



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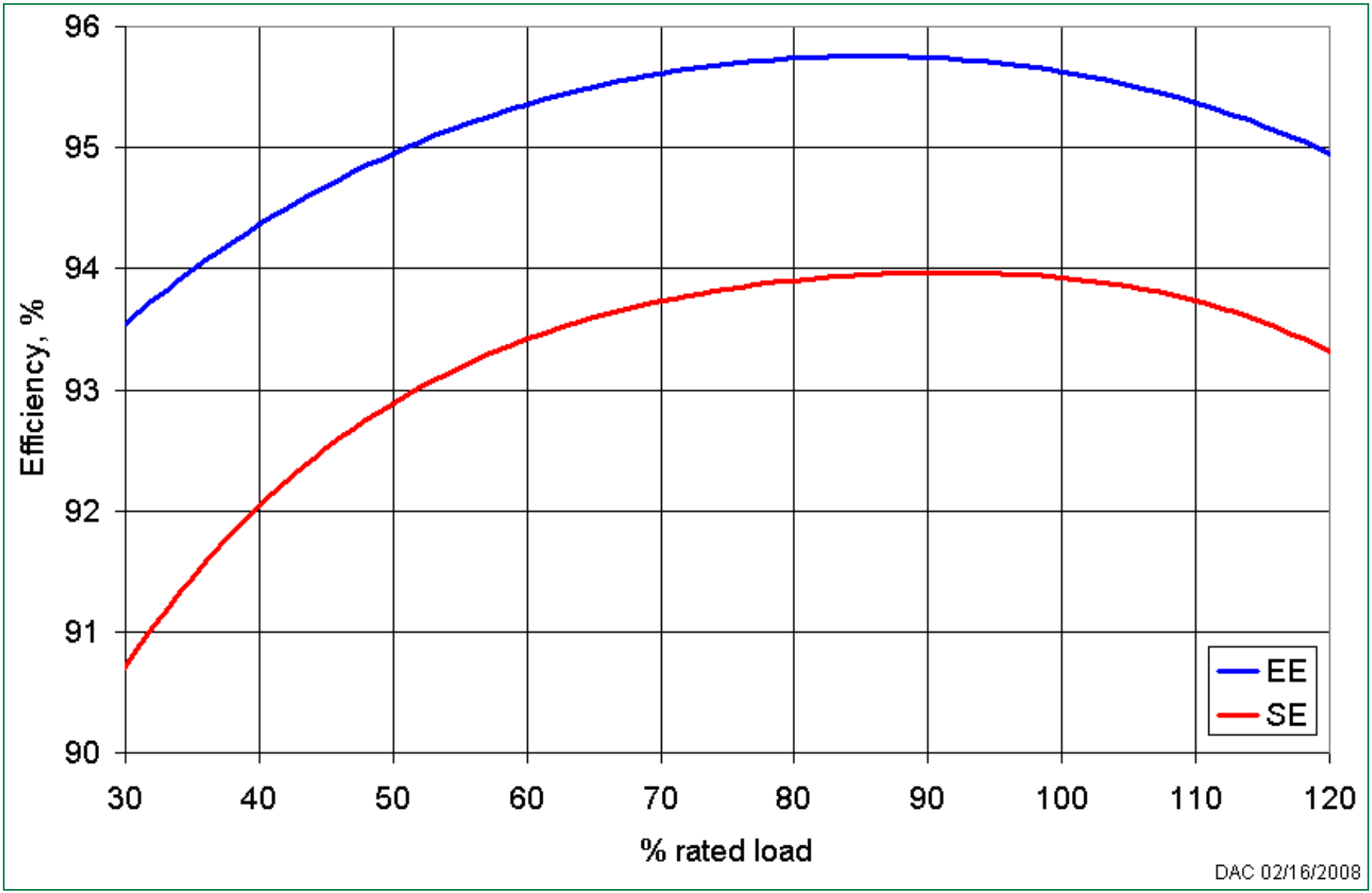
Typical motor efficiencies for 200 hp, 4-pole motors over the normal pump load range



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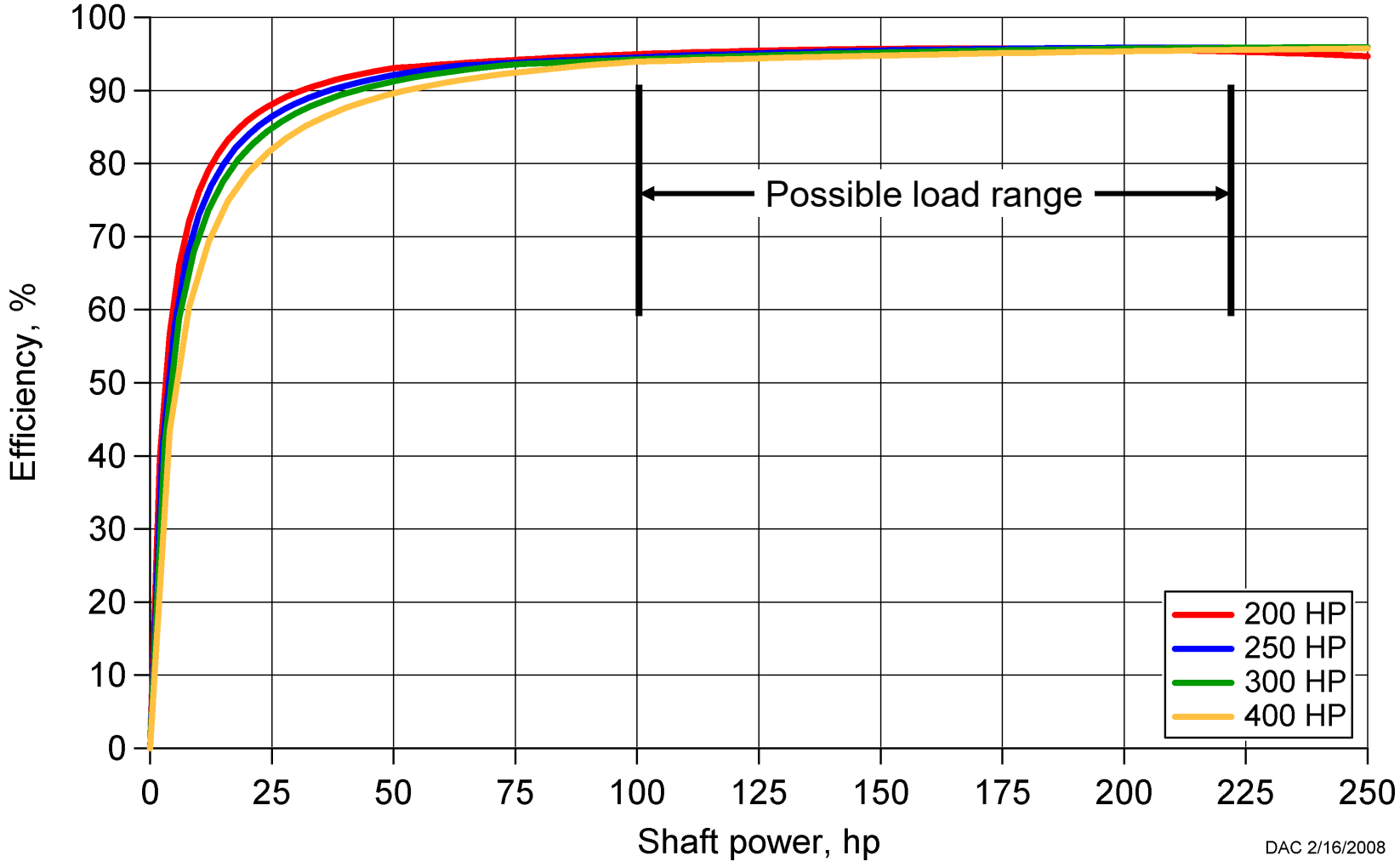
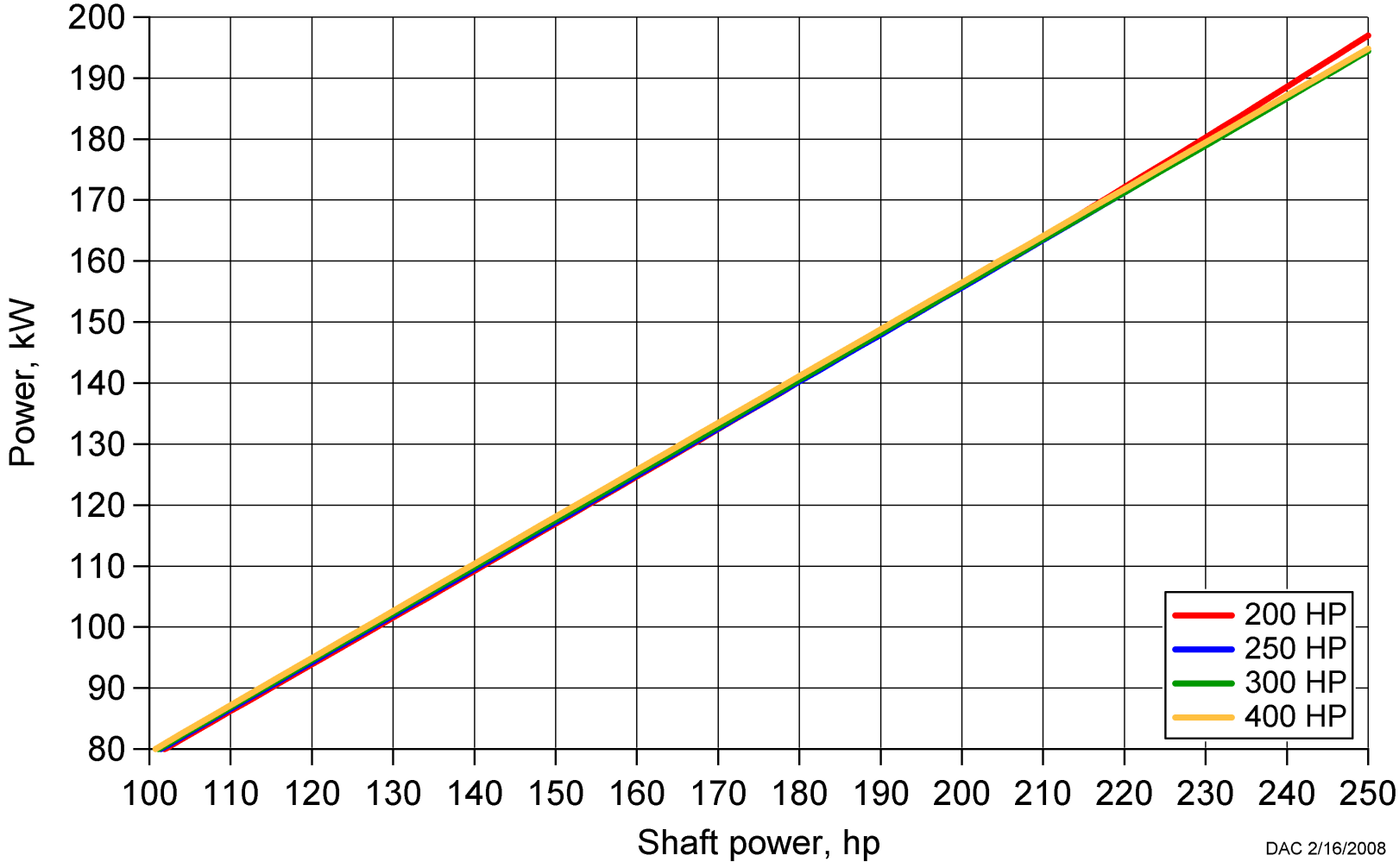
What would be the effect of an oversized motor on motor efficiency?



For this size equipment, the efficiency difference is miniscule – an order of magnitude less than the errors of high quality field measurements

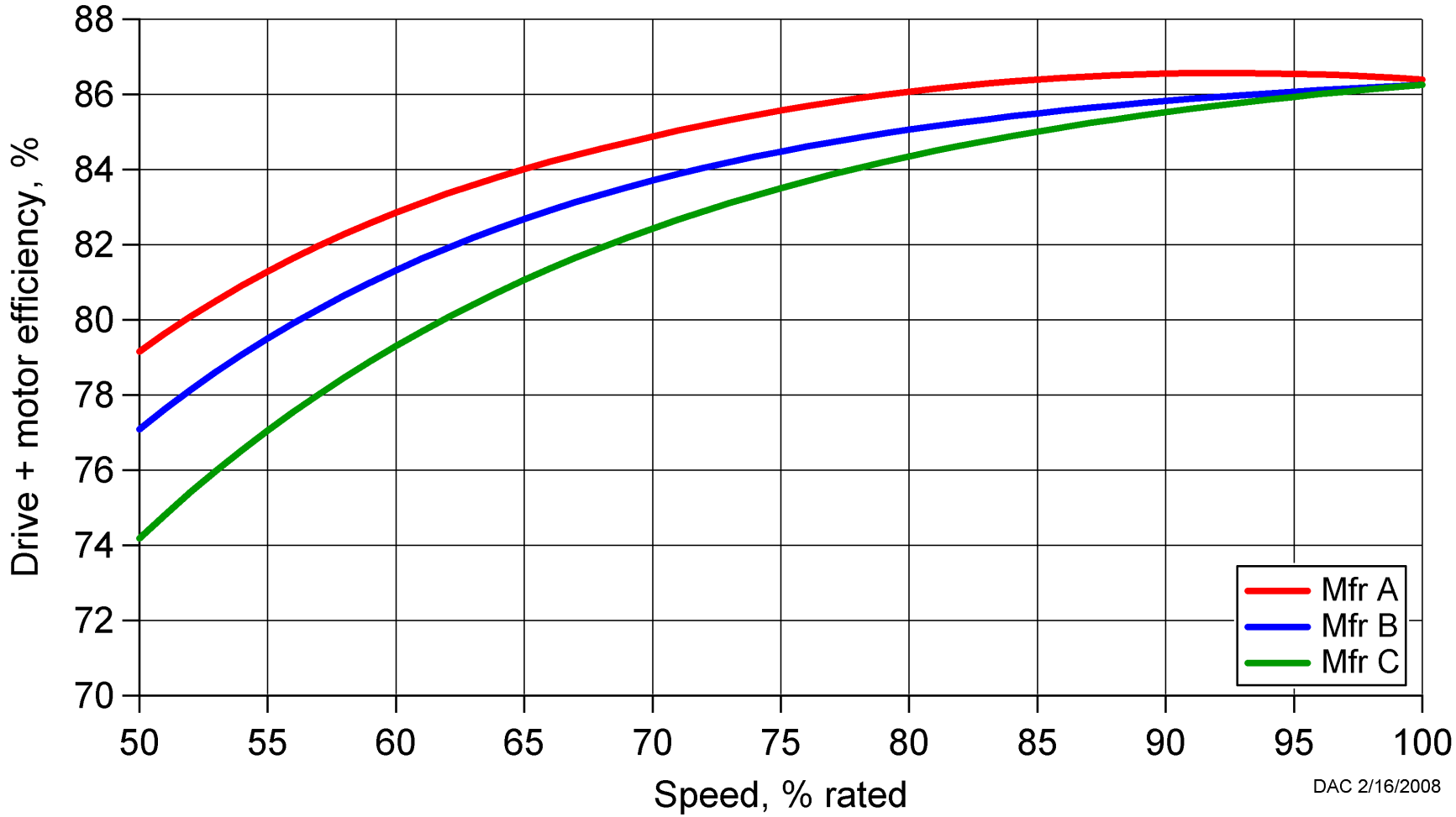
The difference in electric power consumption from oversized motors is trivial



NOTE: The effect of oversizing the pump can be tremendously important, so never attempt to apply this pattern to the other side of the coupling.

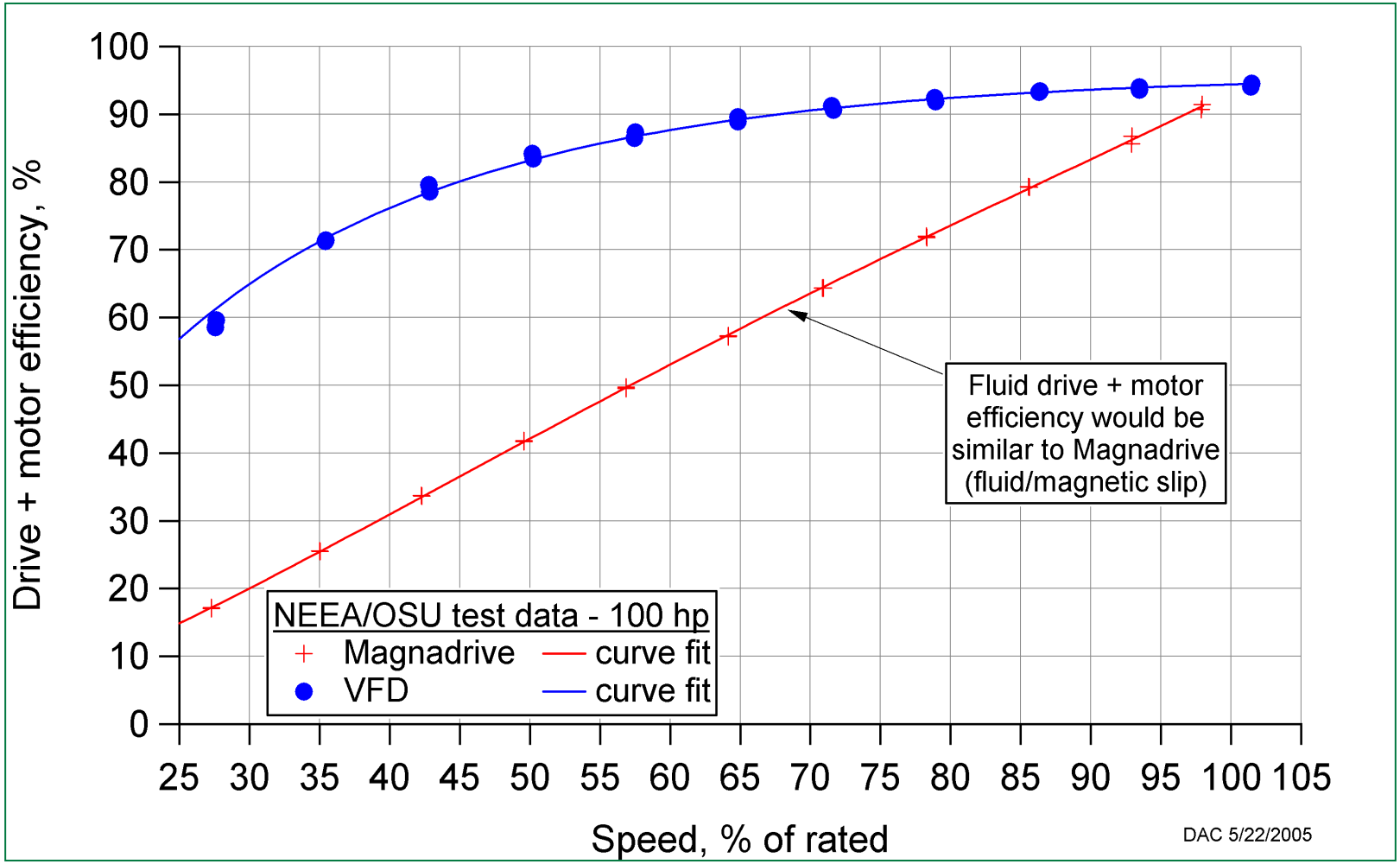
Variable speed drive performance characteristics

Combined motor & adjustable frequency drive results demonstrate high drive efficiencies



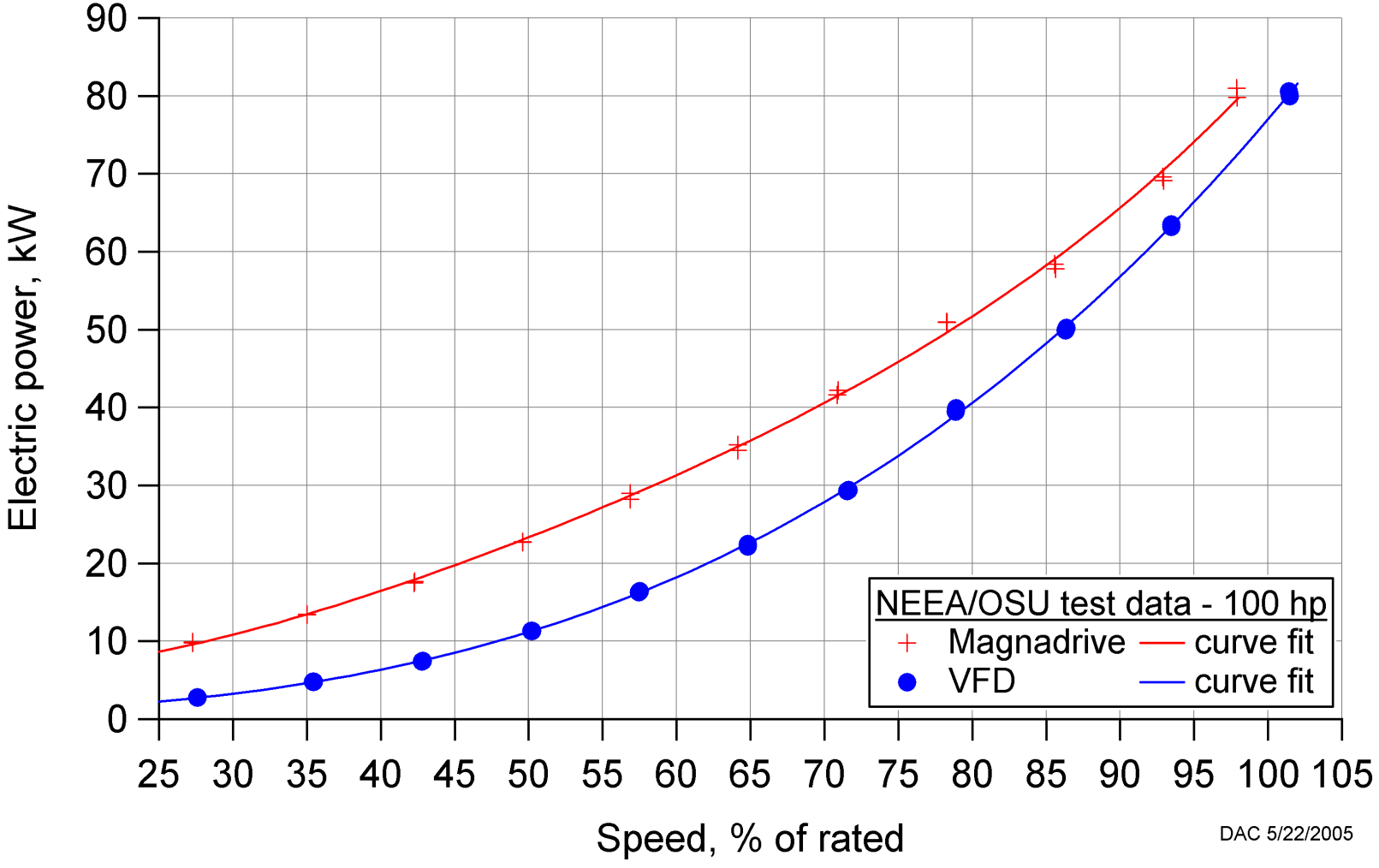
Source: Tests conducted at Y-12 plant motor test facility by Don Casada, Oak Ridge National Laboratory

Comparison of motor + drive efficiencies: AFD and mechanical-side drives



Source:Product Testing: Northwest Energy Efficiency Alliance, Report 00-048, by Oregon State University, March 2000.

But drive efficiency can be misleading - what is more important is the effect on power



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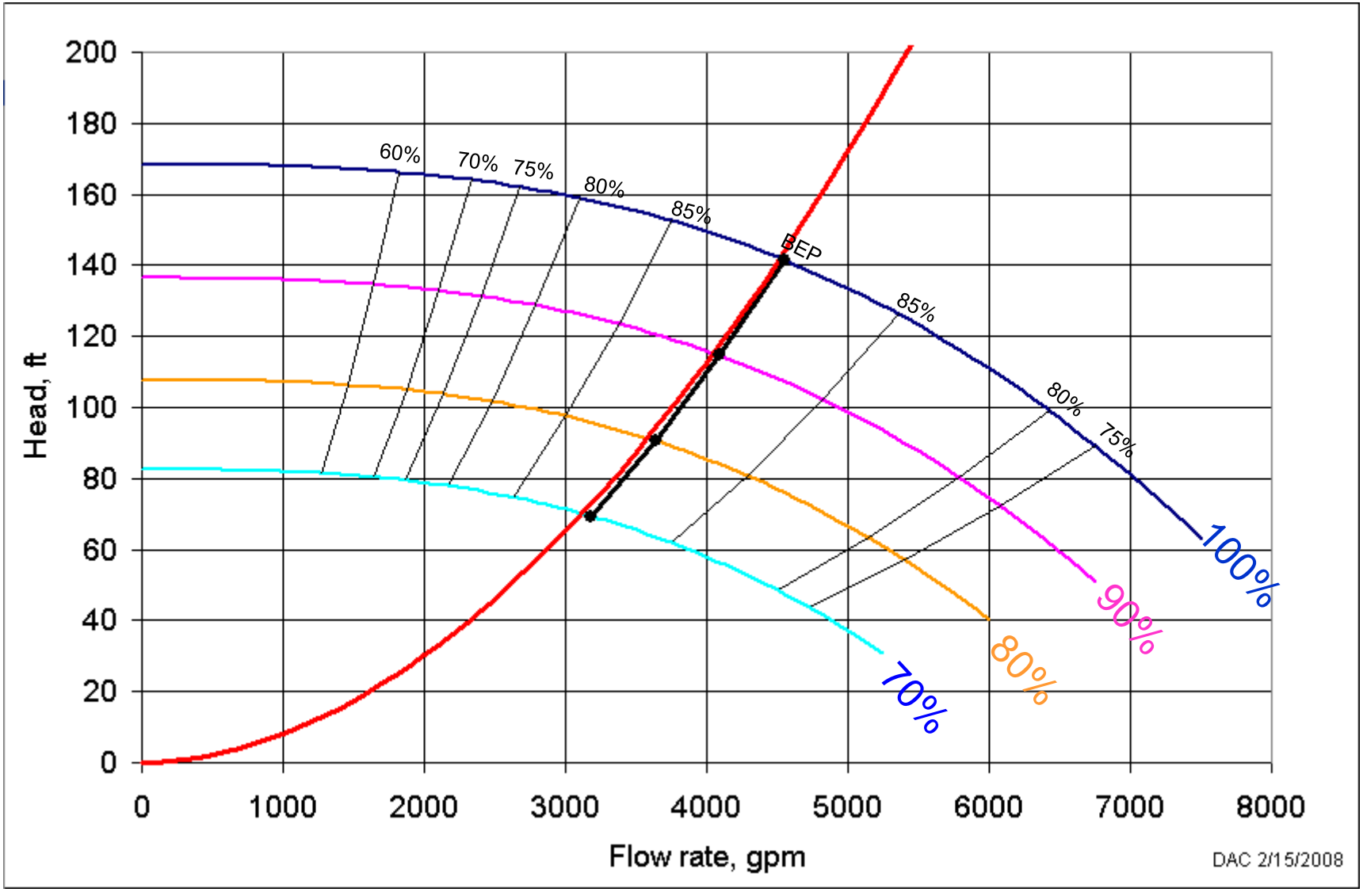
What happens if we reduce pump speed in the three systems types mentioned earlier?

Change in speed for the all frictional system results in maintenance of constant pump efficiency (Pump 2)



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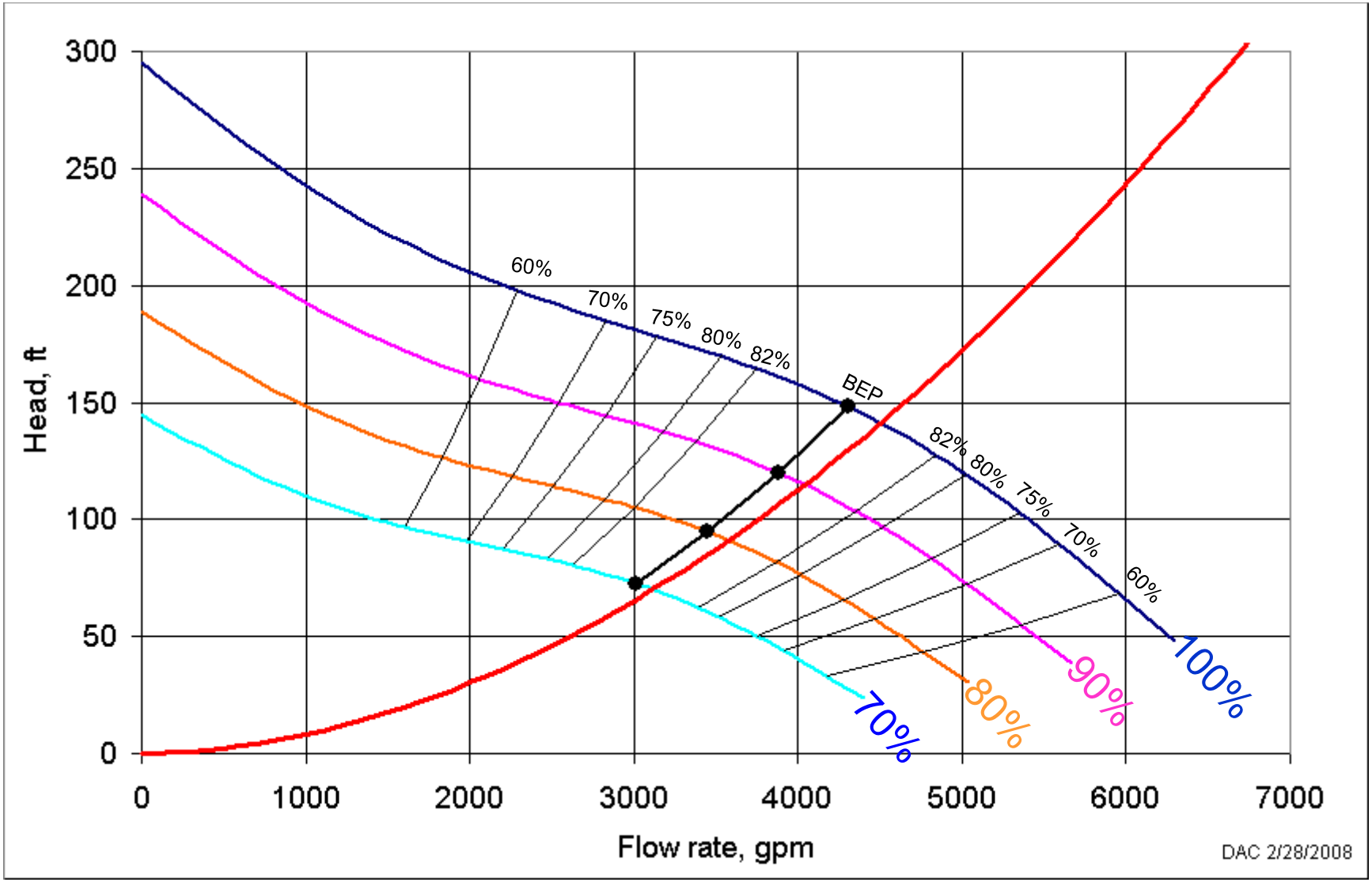
Change in speed for the all frictional system results in maintenance of constant pump efficiency (Pump 3)



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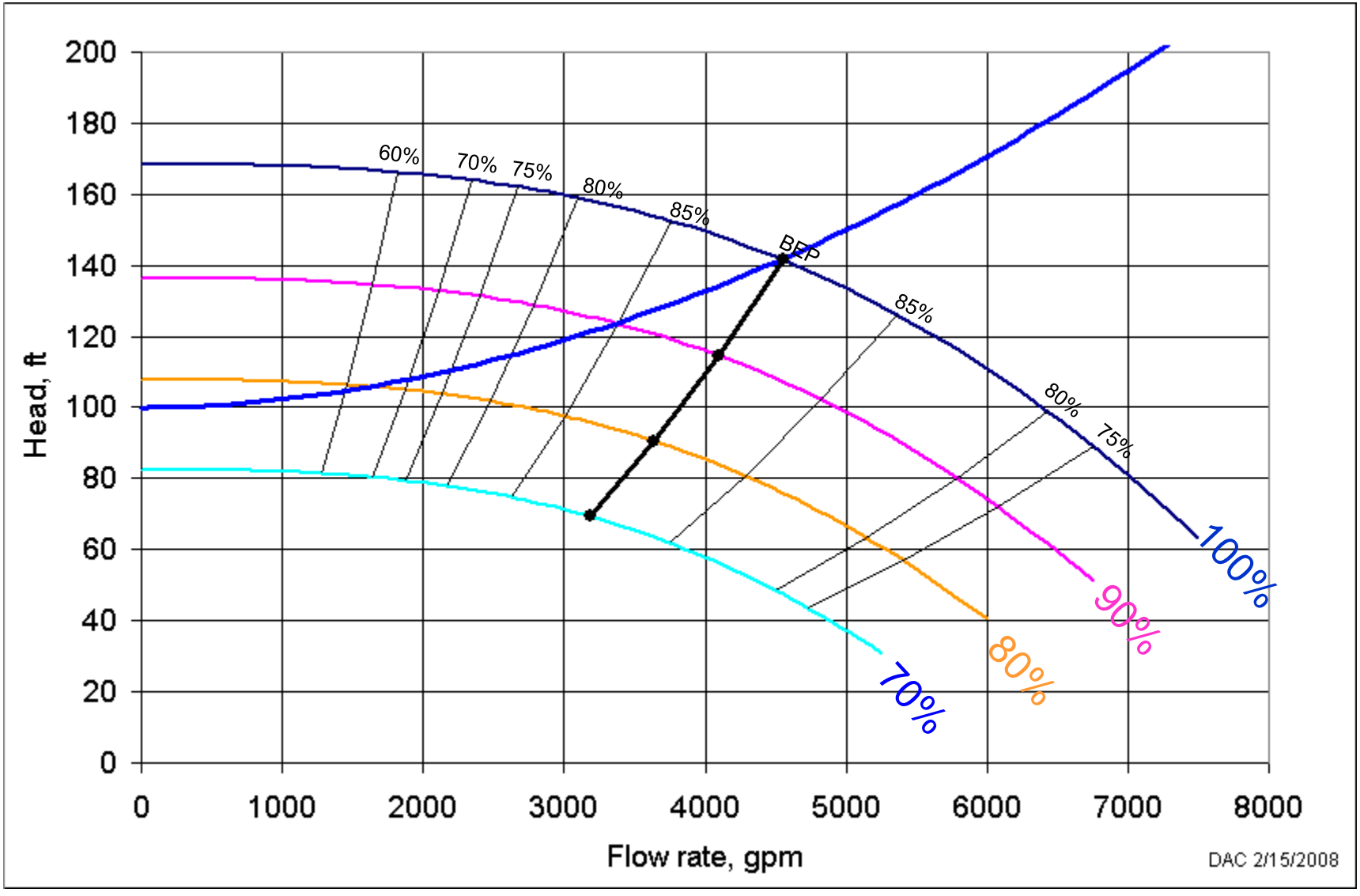
Change in speed for the 100-ft static system with Pump 2 results in loss of flow at ~78% speed



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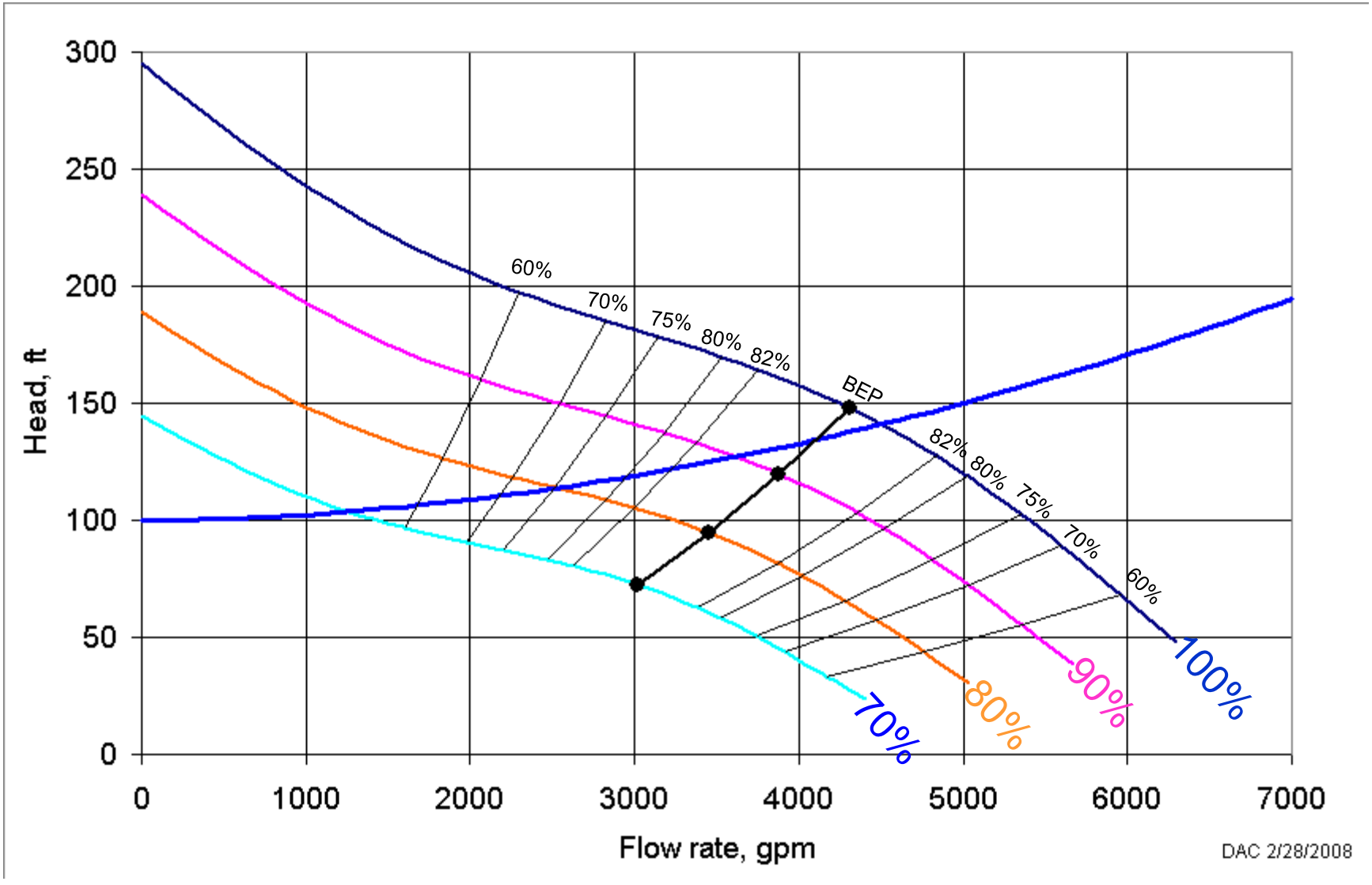
The steeper head-capacity curve for pump 3 makes for improved turndown and controllability



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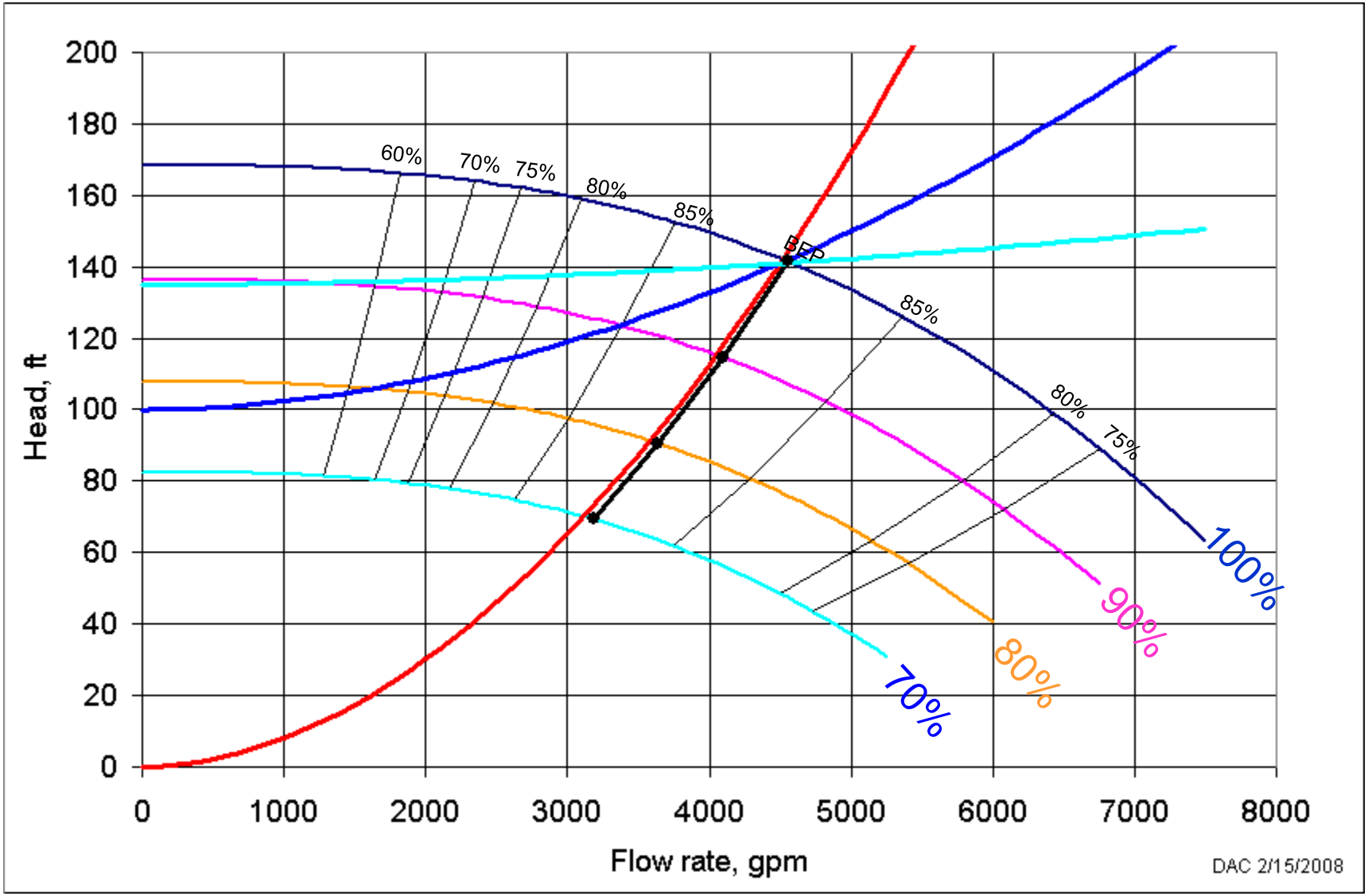
All three system curves with P2, variable speed



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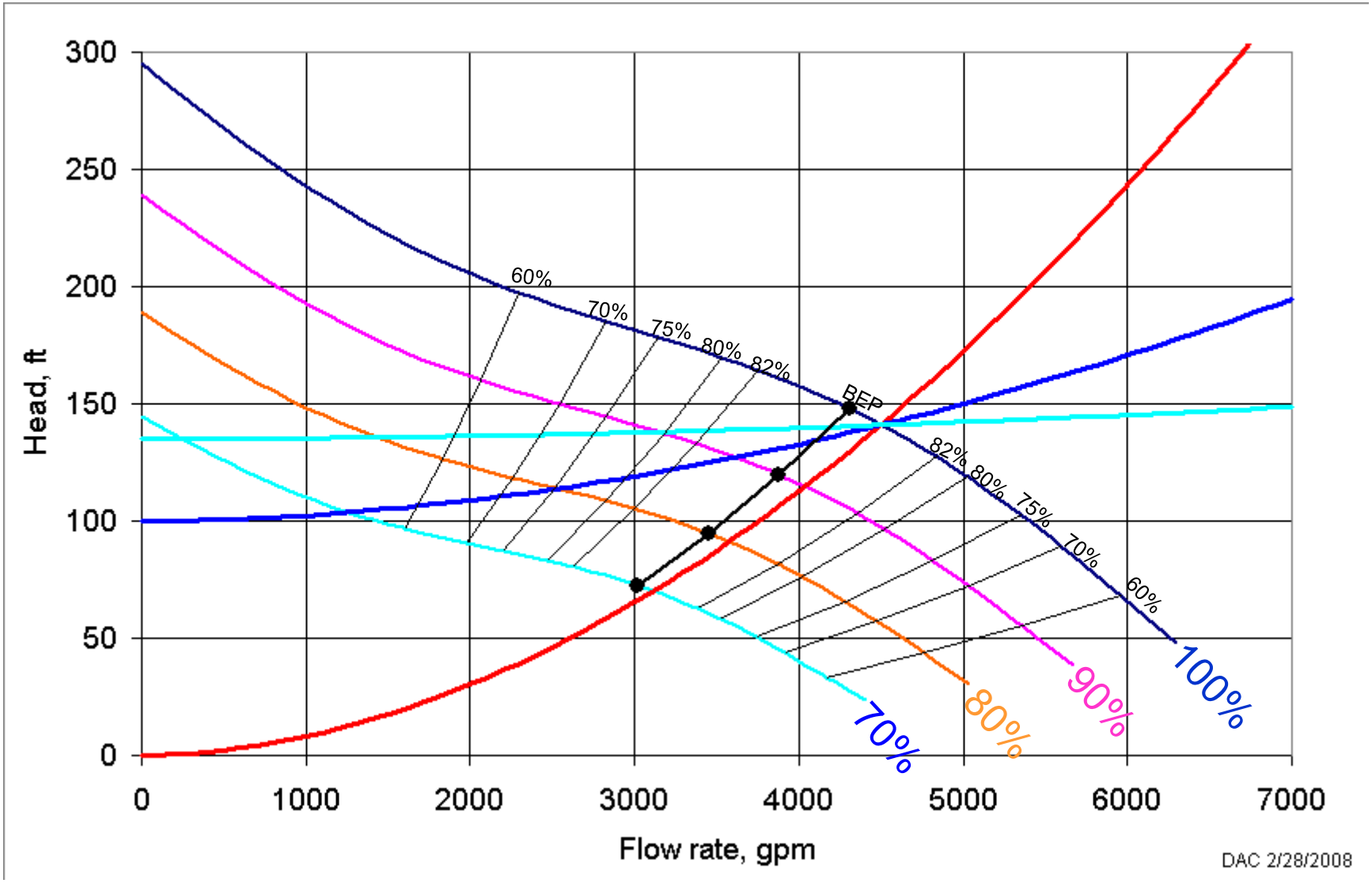
All three system curves with P3, variable speed



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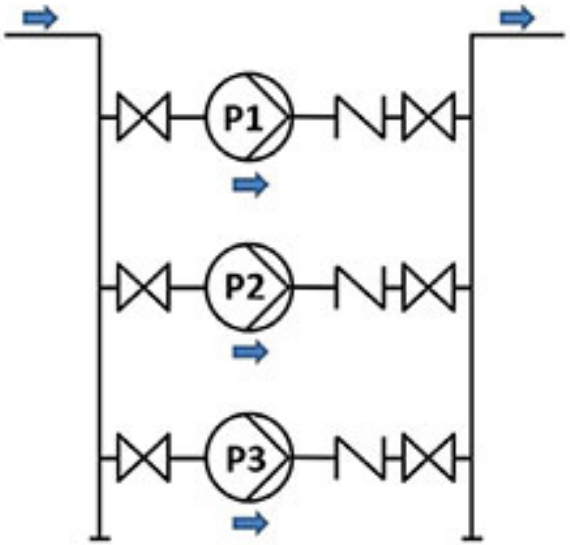
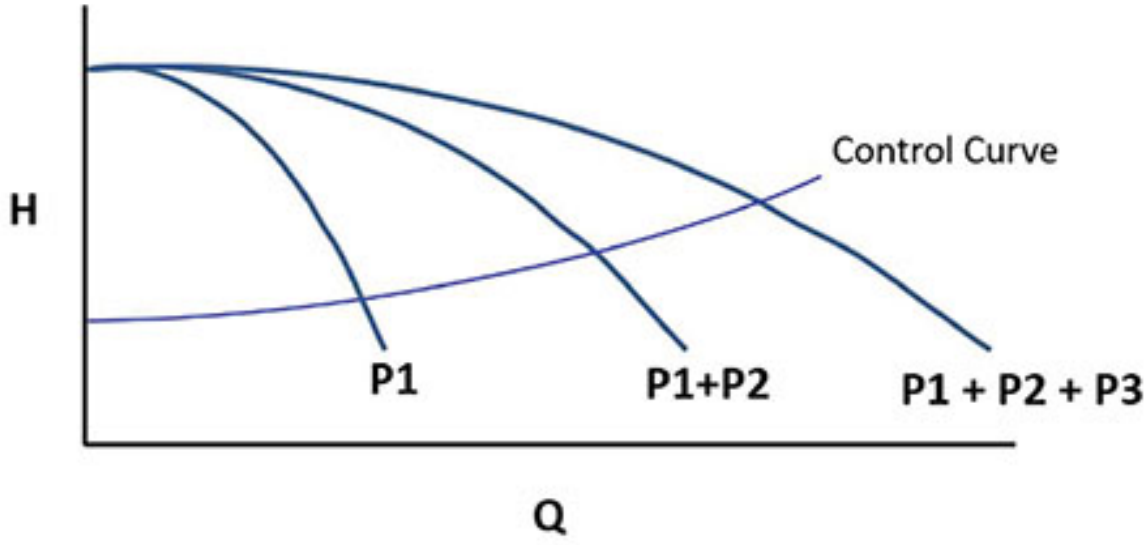
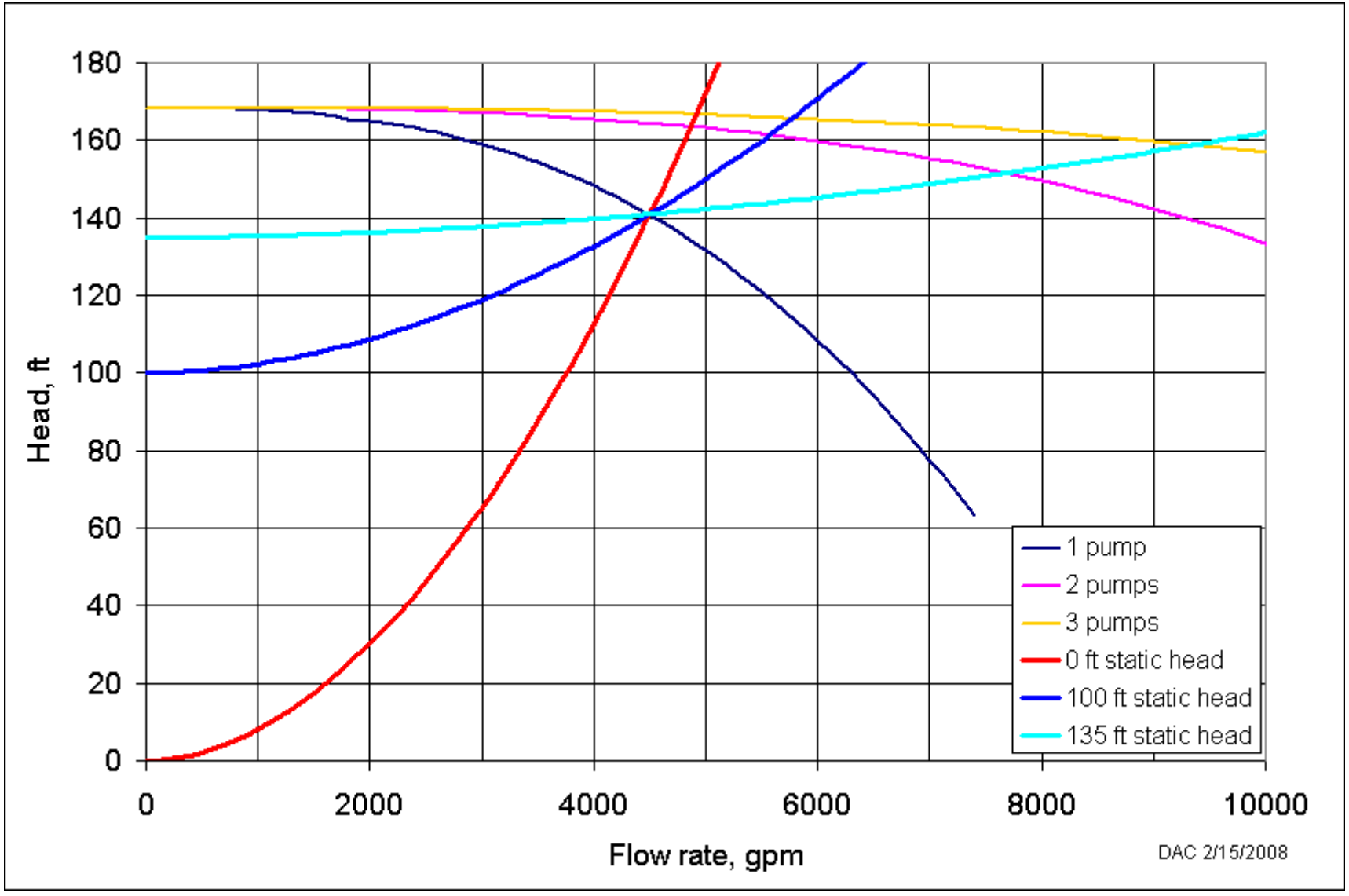
How about parallel pump operation with different system types?





Parallel pump response also depends on the nature of the system and pump curves (P2)



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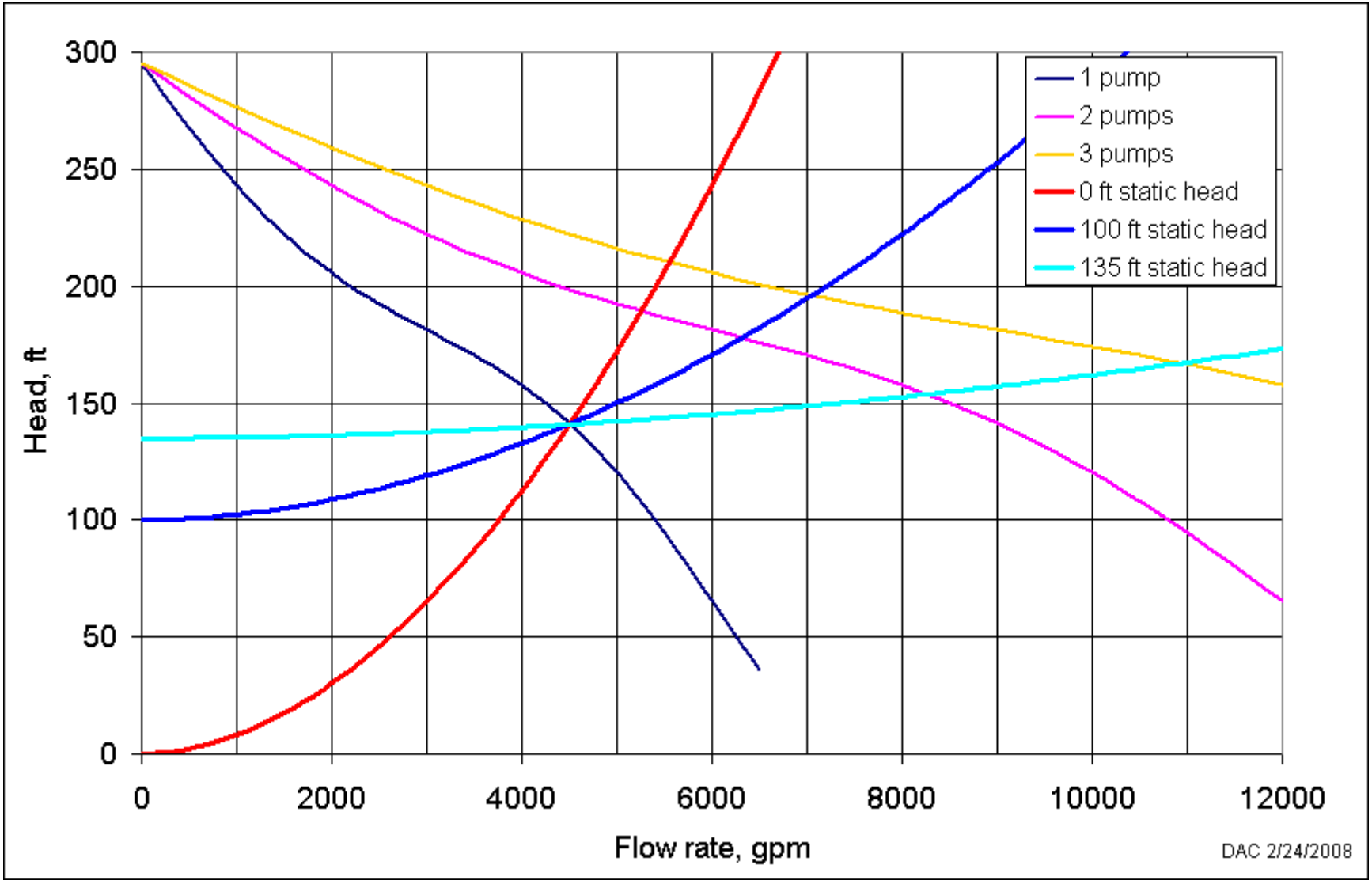
Parallel pump response also depends on the nature of the system and pump curves (P3)



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An Introduction to the Pumping Assessment Tool in MEASUR

- Goal: to assist pump users in quantifying potential energy and cost savings
- Relies on process or field-measured fluid and electrical data
- Hydraulic Institute pump efficiency-estimating algorithms used to estimate achievable pump efficiency
- Published motor manufacturer data (motors in the Motormaster database plus other published motor data) were used to develop curve fit-based performance predictions

Open the MEASUR Software

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Energy Efficiency & Renewable Energy

Add New

Home

- All Assessments
  - Virtual In-plant Training Examples
    - Intro to MEASUR
  - TVA Workshop Boiler 2
  - TVA Workshop Boiler
  - ADM
    - Fan OSB Combustion Air Fan
    - Fan Test
  - Berry Global
  - Uberlandia - Boiler
  - Uberlandia
  - Red Star Cedar Rapids
  - Lloydminster
  - Uberlandia Boiler Pump
  - ADM
    - Red Star Cedar Rapids
    - Lloydminster
  - Demo 2020
  - Lloydminster
  - Lloydminister Increase Boiler Pressure to
  - Lloydminister Boiler #3
  - Lloydminister Boiler #4
  - Inefficient System
  - ADM Mexico MO

MEASUR

Welcome to the most efficient way to manage and optimize your facilities' systems and equipment.

Create an assessment to model your system and find opportunities for efficiency or run calculations from one of our many property and equipment calculators.
Get started with one of the following options.

Create Assessment
Model a system and explore multiple optimization scenarios.

- **Create Pump Assessment**
  formerly DOE Pumping System Assessment Tool (PSAT)
- **Create Process Heating Assessment**
  formerly DOE Process Heating Assessment and Survey Tool (PHAST)
- **Create Fan Assessment**
  formerly DOE Fan System Assessment Tool (FSAT)

Properties & Equipment Calculators
Generate detailed properties and test a variety of adjustments.

- Motors
- Process Cooling
- Pumps
- Fans
- Process Heating
- Steam
- Compressed Air
- Lighting
- Waste Water
- General

Inventory Management
Create and manage equipment inventory.

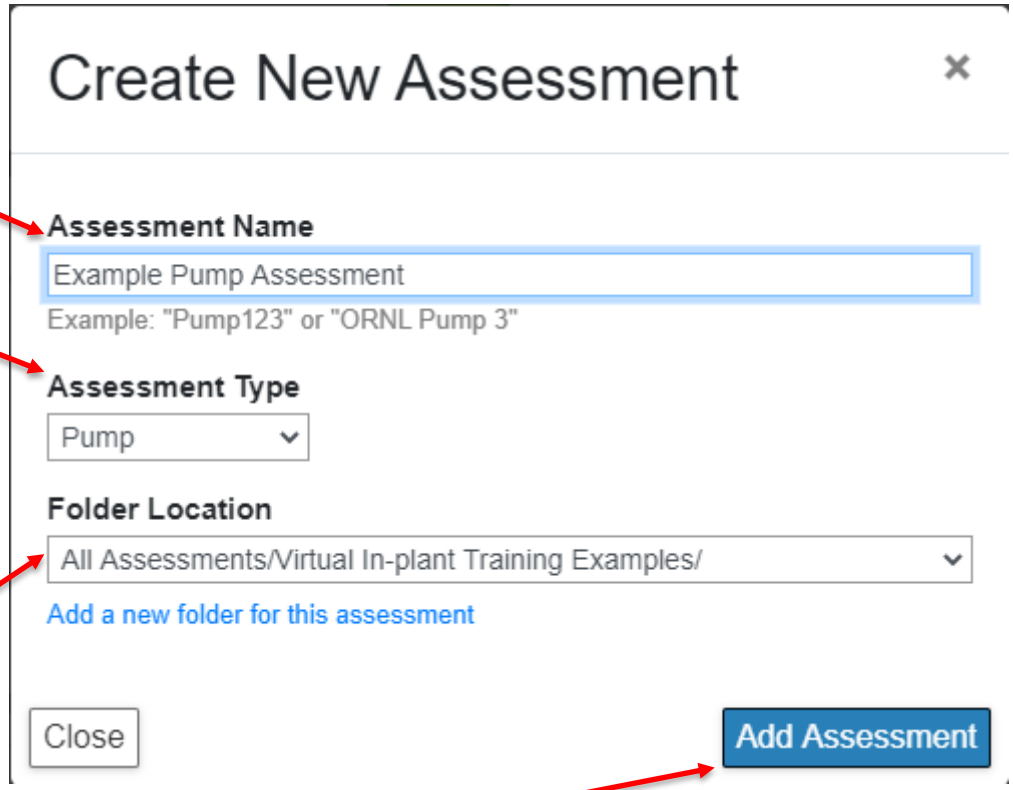
Click on Create Pump Assessment

Create New Pump Assessment

Name the Assessment

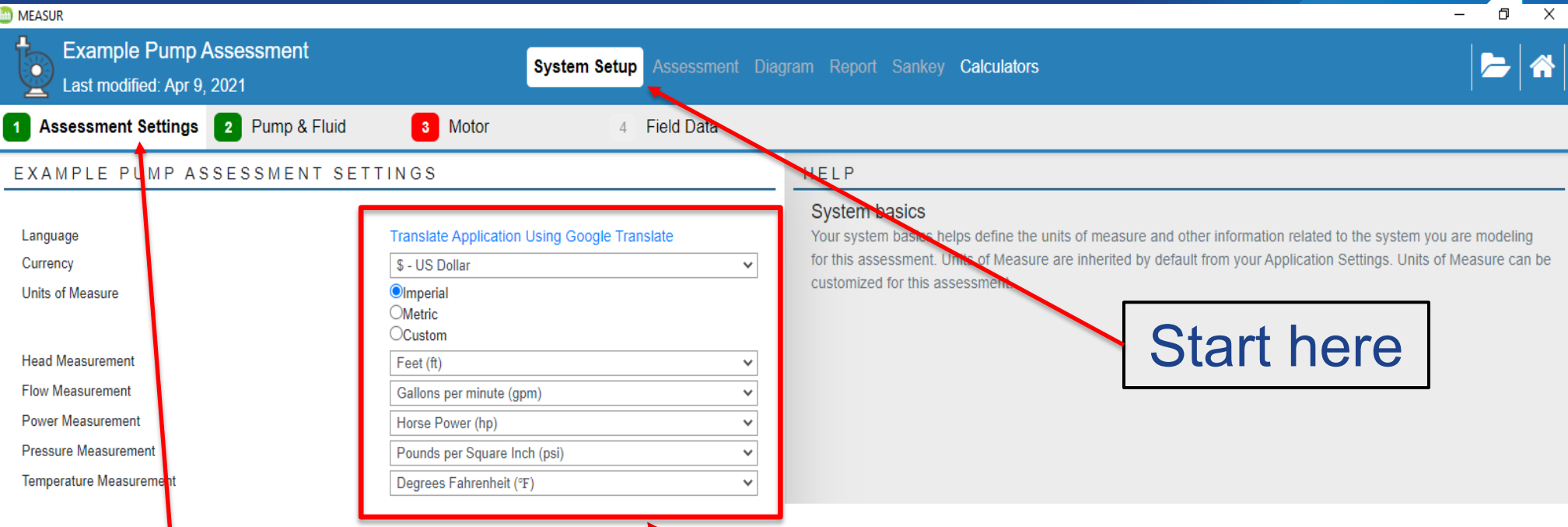
Select the Assessment Type

Select where you want the file saved on your computer



Finally, Click on Add Assessment

System Setup – Assessment Settings



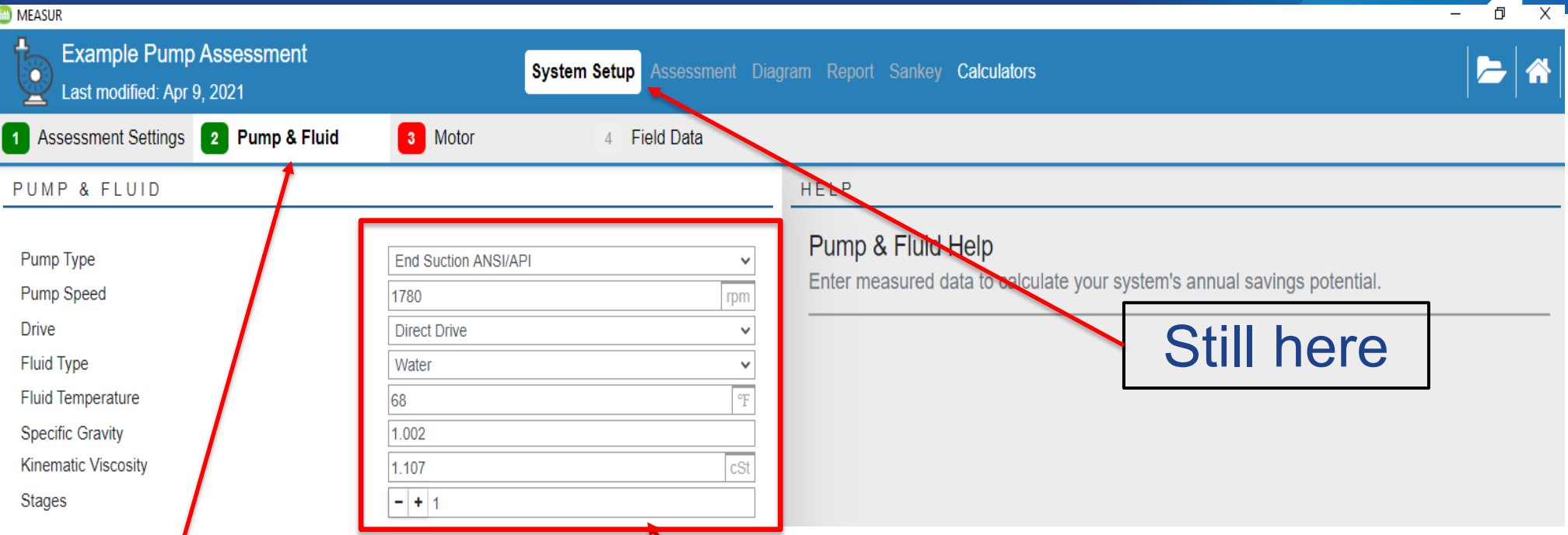
Start here

Then here

Select the language and units you want to work with

Finally, Click on Pump & Fluid to continue

System Setup – Pump & Fluid



Still here

Now here

Input pump and fluid information

Finally, Click on Motor to continue

System Setup – Motor

MEASUR

Example Pump Assessment
Last modified: Apr 9, 2021

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

1 Assessment Settings | 2 Pump & Fluid | 3 Motor | 4 Field Data

MOTOR

Line Frequency	60 Hz
Rated Motor Power	200 hp
Motor RPM	1780 rpm
Efficiency Class	Energy Efficient
Rated Voltage	460 V
Full-Load Amps	225.8 A

Estimate Full-Load Amps

HELP

Motor Help

Enter measured data to calculate your system's annual savings potential.

Full Load Amps

Full Load Amps represent either the known or estimated amps. This value will be used as a normalizing value in the Field Data section if Current is the selected Load estimation method.

If the Full-Load Amps is not known, an estimate can be made by clicking the "Estimate Full-Load Amps" button.

Note: The correct Rated Voltage, Rated Motor Power, and Motor RPM should be entered before the button is pressed. If any of these values change (either in the baseline or when creating a scenario), this button should be used again.

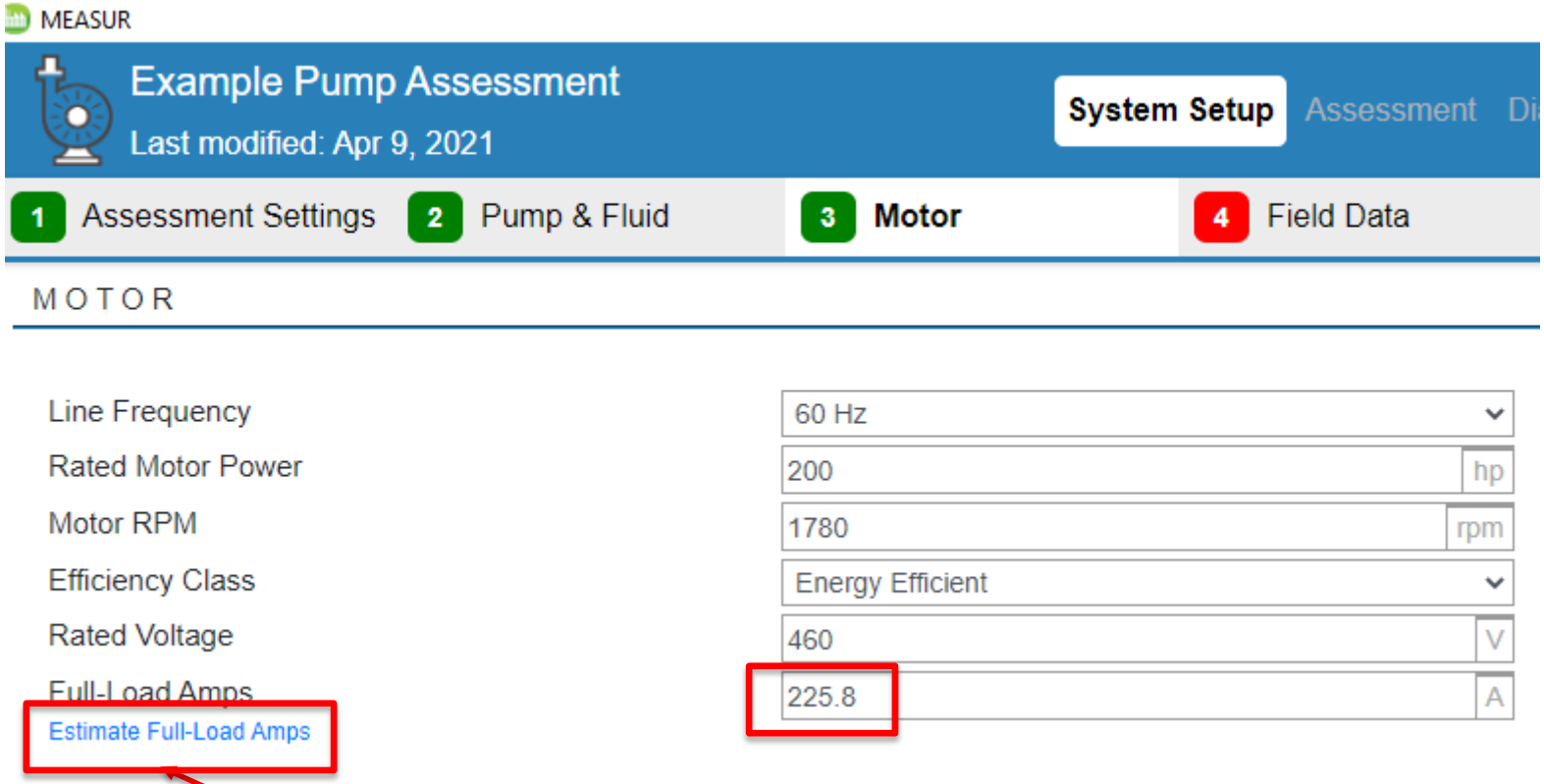
Still here

Now here

Input Motor information

Finally, Click on Field Data to continue

System Setup – Estimate Full Load Amps



Can estimate full load motor amps by clicking here

System Setup – Field Data

MEASUR

Example Pump Assessment
Last modified: Apr 9, 2021

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

Still here

1 Assessment Settings | 2 Pump & Fluid | 3 Motor | 4 Field Data

FIELD DATA

Operating Hours	8760	hrs/yr
Electricity Cost	0.080	$/kWh
Flow Rate	2000	gpm
Head (Calculate Head)	277	ft
Load Estimation Method	Power	
Motor Power	135	kW
Measured Voltage	460	V

RESULTS | HELP

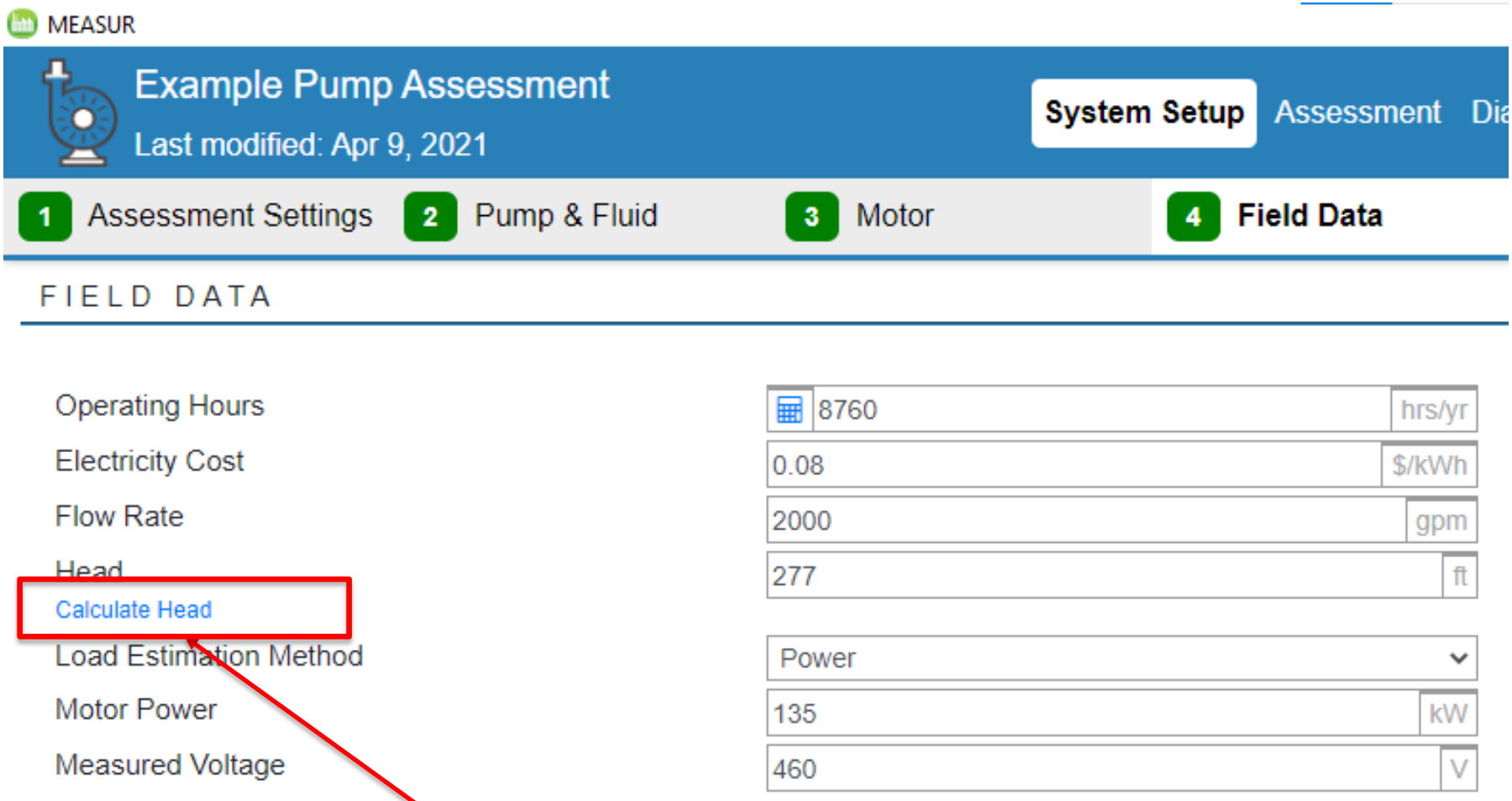
	Baseline
Percent Savings (%)	— —
Pump efficiency (%)	80.9
Motor rated power (hp)	200
Motor shaft power (hp)	173.3
Pump shaft power (hp)	173.3
Motor efficiency (%)	95.8
Motor power factor (%)	86
Percent Loaded (%)	87
Drive efficiency (%)	100
Motor current (amps)	197
Motor power (kW)	135
Annual Energy (MWh)	**1,183**
Annual Energy Savings (MWh)	**—**
Annual Cost	**$94,608**
Annual Savings	**—**

Input Field Data

Baseline Results

After Field Data, move on to the assessment

System Setup – Calculate Pump Head



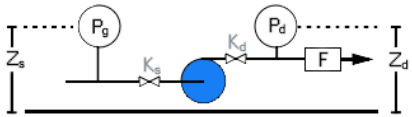
Go to the pump head calculator by clicking here

System Setup – Pump Head Calculator

MEASUR

PUMP HEAD TOOL

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	1.002		
Flow Rate	2000	gpm	
Suction		**Discharge**	
Pipe diameter (ID)	12 in	Pipe diameter (ID)	12 in
Gauge pressure (P_g)	5 psi	Gauge pressure (P_d)	124.8 psi
Gauge elevation (Z_s)	10 ft	Gauge elevation (Z_d)	10 ft
Line loss coefficients (K_s)	0.5	Line loss coefficients (K_d)	1

RESULTS | HELP

Result Data

Differential Elevation Head	0.0 ft
Differential Pressure Head	276.28 ft
Differential Velocity Head	0.0 ft
Estimated Suction Friction Head	0.25 ft
Discharge Friction Head	0.5 ft
Pump Head	277.03 ft

Copy Table

Input Field Data

Pump Head

Two Different Geometries: Suction Gauge

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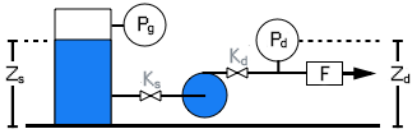
System Setup – Pump Head Calculator

MEASUR

PUMP HEAD TOOL

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	1.002	
Flow Rate	2000	gpm

Suction			Discharge		
Pipe diameter (ID)	12	in	Pipe diameter (ID)	12	in
Tank gas overpressure (P_g)	0	psi	Gauge pressure (P_d)	124	psi
Tank fluid surface elevation (Z_s)	10	ft	Gauge elevation (Z_d)	10	ft
Line loss coefficients (K_s)	0.5		Line loss coefficients (K_d)	1	

RESULTS | HELP

Result Data

Differential Elevation Head	0.0 ft
Differential Pressure Head	285.97 ft
Differential Velocity Head	0.5 ft
Estimated Suction Friction Head	0.25 ft
Discharge Friction Head	0.5 ft
Pump Head	287.22 ft

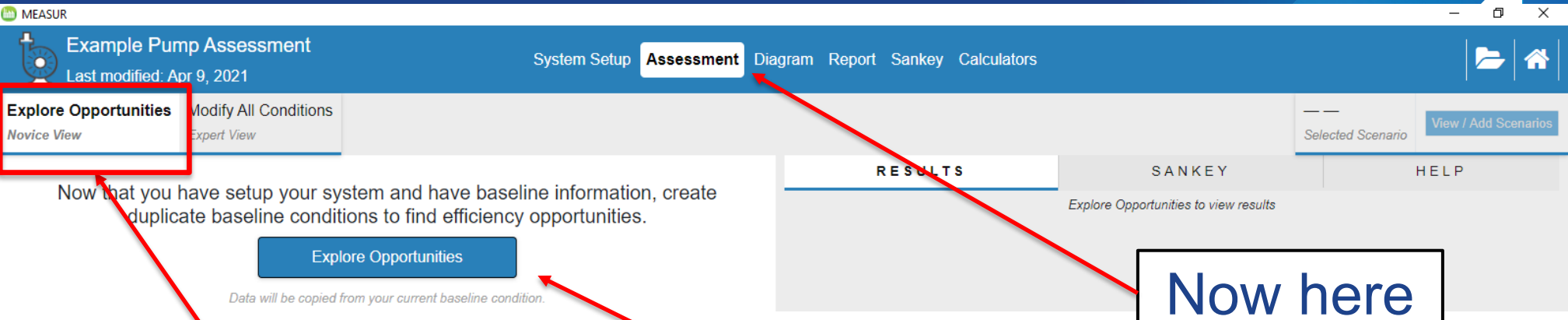
Copy Table

Input Field Data

Pump Head

Two Different Geometries: Suction Tank

Assessment View – Novice



Now here

Novice View

Click Explore Opportunities to evaluate a potential project

Evaluate Potential Project

Name the Opportunity

Add New Scenario

The Modify All Conditions section is an expert view, allowing you to change any input. You can create many different scenarios, to compare changes to your system. Notes for each loss page can be added in the right tab (NOTES), these will be added to your final report. Data will be copied from your current baseline condition.

Scenario Name: Trim Impeller and Open Throttled Va

Create

Click on Create

Assessment View – Novice

MEASUR

Example Pump Assessment
Last modified: Apr 9, 2021

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

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

Trim Impeller and Open Throttled 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: Trim Impeller and Open Throttled Valve

- ☐ Install VFD
- ☐ Install More Efficient Drive
- ☐ Install More Efficient Pump
- ☐ Reduce System Flow Rate
- ☐ Reduce System Head Requirement
- ☐ Adjust Operational Data
- ☐ Install More Efficient Motor

RESULTS | SANKEY | HELP

	Baseline	Trim Impeller and Open Throttled Valve
Percent Savings (%)	— —	
Pump efficiency (%)	80.9	80.9
Motor rated power (hp)	200	200
Motor shaft power (hp)	173.3	173.3
Pump shaft power (hp)	173.3	173.3
Motor efficiency (%)	95.8	95.8
Motor power factor (%)	86	86
Percent Loaded (%)	87	87
Drive efficiency (%)	100	100
Motor current (amps)	197	197
Motor power (kW)	135	135
Annual Energy (MWh)	**1,183**	**1,183**
Annual Energy Savings (MWh)	**—**	**00**
Annual Cost	**$94,608**	**$94,605**
Annual Savings	**—**	**$03**

Select the type of project

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Assessment View – Novice

MEASUR

Example Pump Assessment
Last modified: Apr 9, 2021

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

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

Trim Impeller and Open Throttled 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: Trim Impeller and Open Throttled Valve

☑ Install VFD

Project Type Selected

Baseline	Modifications
Flow Rate: 2,000 gpm	Flow Rate: 2000 gpm
Head: 277 ft	Head (Calculate Head): 227 ft
Motor Drive: Direct Drive	Drive Efficiency: 100 %
Pump Type: End Suction ANSI/API	Pump Efficiency (Optimize Pump): 80.87 %

Can adjust pump efficiency

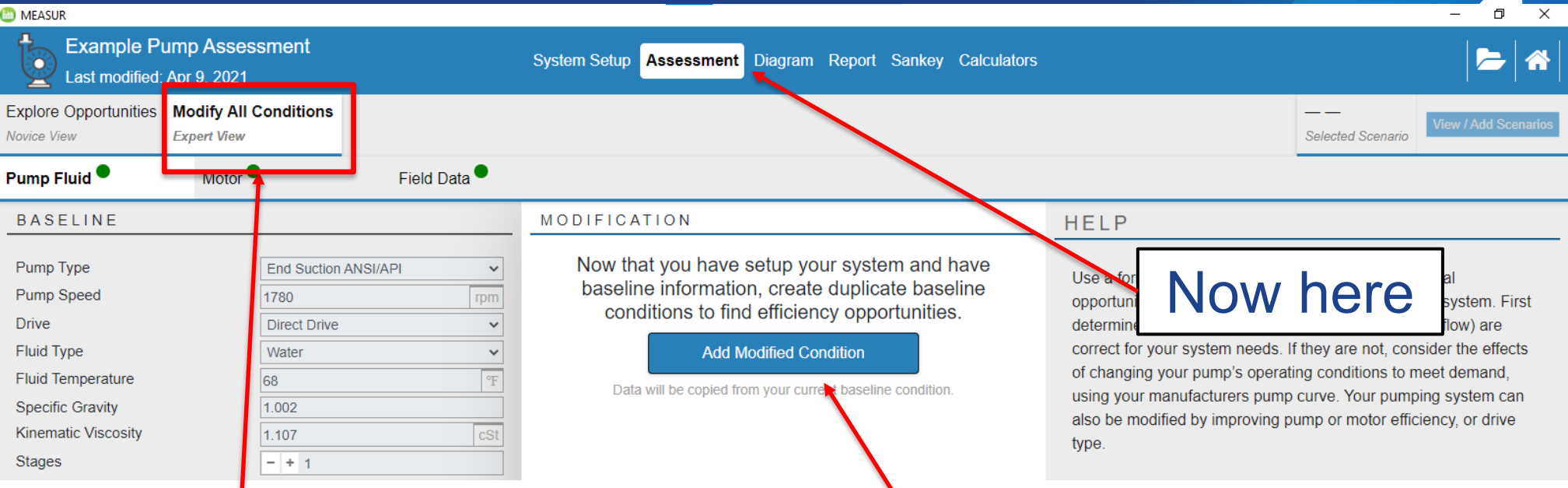
The efficiency of your pump has been calculated based on your system setup. Either directly modify your efficiency or click "Optimize Pump" to estimate your pump efficiency based on a different pump type.

RESULTS | SANKEY | HELP

	Baseline	Trim Impeller and Open Throttled Valve
Percent Savings (%)	— —	18.0%
Pump efficiency (%)	80.9	80.9
Motor rated power (hp)	200	200
Motor shaft power (hp)	173.3	142
Pump shaft power (hp)	173.3	142
Motor efficiency (%)	95.8	95.6
Motor power factor (%)	86	84.2
Percent Loaded (%)	87	71
Drive efficiency (%)	100	100
Motor current (amps)	197	165
Motor power (kW)	135	110.8
Annual Energy (MWh)	**1,183**	**970**
Annual Energy Savings (MWh)	**—**	**212**
Annual Cost	**$94,608**	**$77,630**
Annual Savings	**—**	**$16,978**

Reduce Pump Head by 50 Feet by Trimming the Impeller and Opening the Throttled Valve

Assessment View – Expert



Now here

Expert View

Click Explore Opportunities to evaluate a potential project

Assessment View – Expert

MEASUR

Example Pump Assessment
Last modified: Apr 9, 2021

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

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

Trim Impeller and Open Throttled Valve *Selected Scenario* | View / Add Scenarios

Pump Fluid | Motor | **Field Data**

BASELINE

Operating Hours	8760	hrs/yr
Electricity Cost	0.08	$/kWh
Flow Rate	2000	gpm
Head (Calculate Head)	277	ft
Load Estimation Method	Power	
Motor Power	135	kW
Measured Voltage	460	V

TRIM IMPELLER AND OPEN THROTTLED VALVE

Operating Hours	8760	hrs/yr
Electricity Cost	0.08	$/kWh
Flow Rate	2000	gpm
Head (Calculate Head)	227	ft
Implementation Costs	2000	$

RESULTS | HELP | NOTES

	Baseline	Trim Impeller and Open Throttled Valve
Percent Savings (%)	— —	18.0%
Pump efficiency (%)	80.9	80.9
Motor rated power (hp)	200	200
Motor shaft power (hp)	173.3	142
Pump shaft power (hp)	173.3	142
Motor efficiency (%)	95.8	95.6
Motor power factor (%)	86	84.2
Percent Loaded (%)	87	71
Drive efficiency (%)	100	100
Motor current (amps)	197	165
Motor power (kW)	135	110.8
Annual Energy (MWh)	**1,183**	**970**
Annual Energy Savings (MWh)	**—**	**212**
Annual Cost	**$94,608**	**$77,630**
Annual Savings	**—**	**$16,978**

Cannot adjust pump efficiency here!

Reduce Pump Head by 50 Feet by Trimming the Impeller and Opening the Throttled Valve

Compare Existing Pump to Optimal Pump

MEASUR

Example Pump Assessment
Last modified: Apr 9, 2021

System Setup | Assessment | D

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

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: Trim Impeller and Open Throttled Valve

☑ Install VFD

Baseline	Modifications
Flow Rate: 2,000 gpm	Flow Rate: 2000 gpm
Head: 277 ft	Head: Calculate Head; 277 ft
Motor Drive: Direct Drive	Drive Efficiency: 95 %
Pump Type: End Suction ANSI/API	Pump Efficiency: Optimize Pump; 80.87 %

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.

To evaluate an "optimized" pump based on Hydraulic Institute algorithms click here

Optimize Pump w/ Hydraulic Institute Algorithms

MEASUR

Example Pump Assessment
Last modified: Apr 9, 2021

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

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

Trim Impeller and Open Throttled 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: Trim Impeller and Open Throttled Valve

☑ Install VFD

Baseline	Modifications
Flow Rate: 2,000 gpm	Flow Rate: 2000 gpm
Head: 277 ft	Head: 277 ft (Calculate Head)
Motor Drive: Direct Drive	Drive Efficiency: 100 %
Pump Type: End Suction ANSI/API	Pump Type: End Suction ANSI/API
	Pump Efficiency: 87 % (Known Efficiency)

RESULTS | SANKEY | HELP

	Baseline	Trim Impeller and Open Throttled Valve
Percent Savings (%)	— —	7.0%
Pump efficiency (%)	80.9	87
Motor rated power (hp)	200	200
Motor shaft power (hp)	173.3	161.1
Pump shaft power (hp)	173.3	161.1
Motor efficiency (%)	95.8	95.7
Motor power factor (%)	86	85.5
Percent Loaded (%)	87	81
Drive efficiency (%)	100	100
Motor current (amps)	197	184
Motor power (kW)	135	125.5
Annual Energy (MWh)	**1,183**	**1,099**
Annual Energy Savings (MWh)	**—**	**83**
Annual Cost	**$94,608**	**$87,952**
Annual Savings	**—**	**$6,656**

Same flow and same head – Original Pump Efficiency is 80.9%; Optimal Pump is 87.0%

The End for Session 2