
Incorporating VSDs into Company Policy

IAC Lead Student Meeting

Kurt Hodges

TTU Lead Student

October 11, 2011

Schneider of Smyrna, TN

- Previously updated compressed air and lighting
- Installed demand shedding building automation system
- Seeking ISO 50001 certification
- Save Energy Now Leader
- Finished installation of 1MW Solar Field in July 2011
- Schneider's "Flagship" for energy efficiency

IAC Assessment

Assessment Date:

Sept. 27, 2010

Led by Director, Dr. Glenn Cunningham,
Assistant Director, Dr. Kenneth Currie, and
Lead Student, Kurt Hodges

Other Students:

Anthony Griffith

Aditya Jayanthi

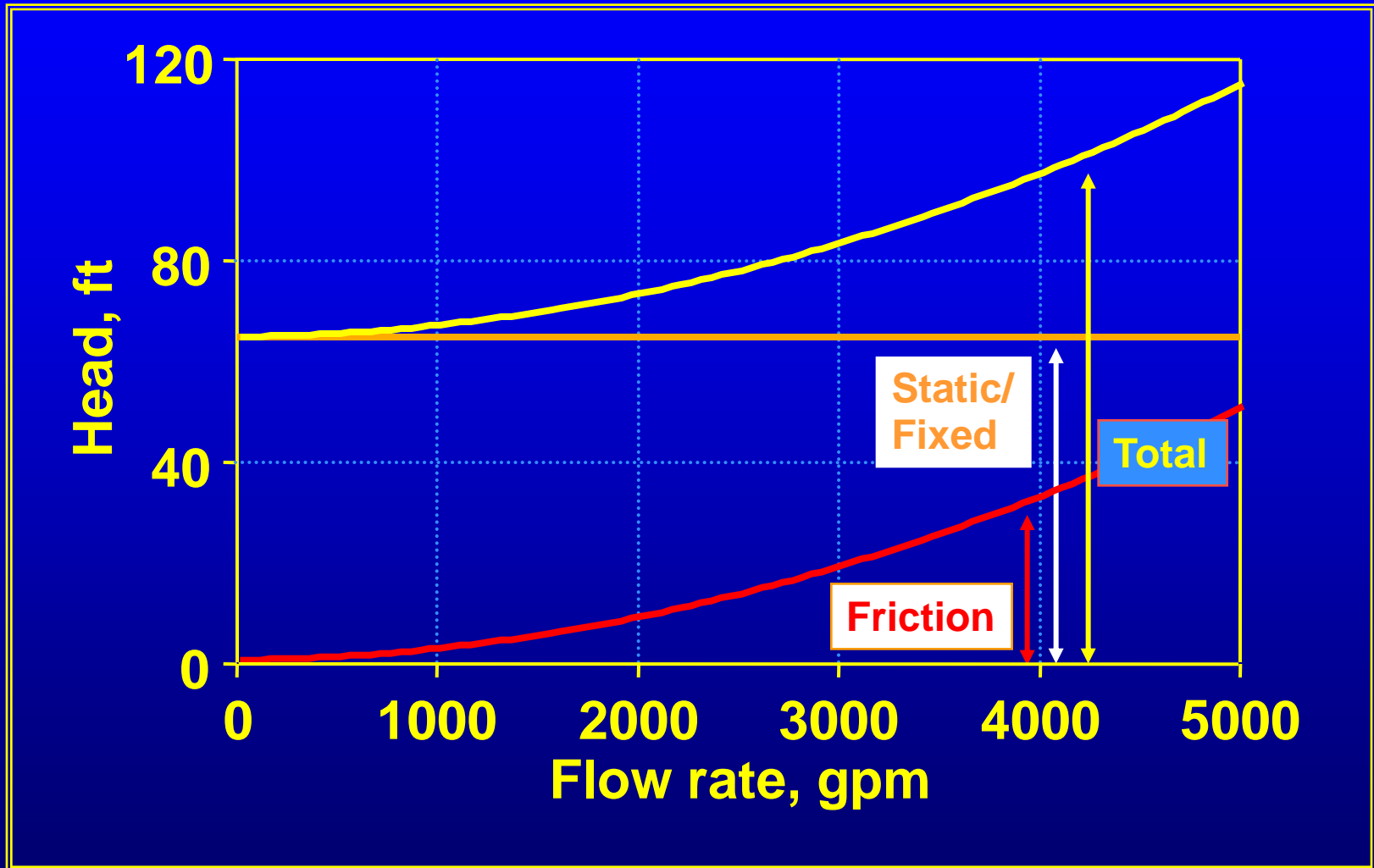
Seth Leedy

7 Parts Washer Pumps with Throttled Discharge

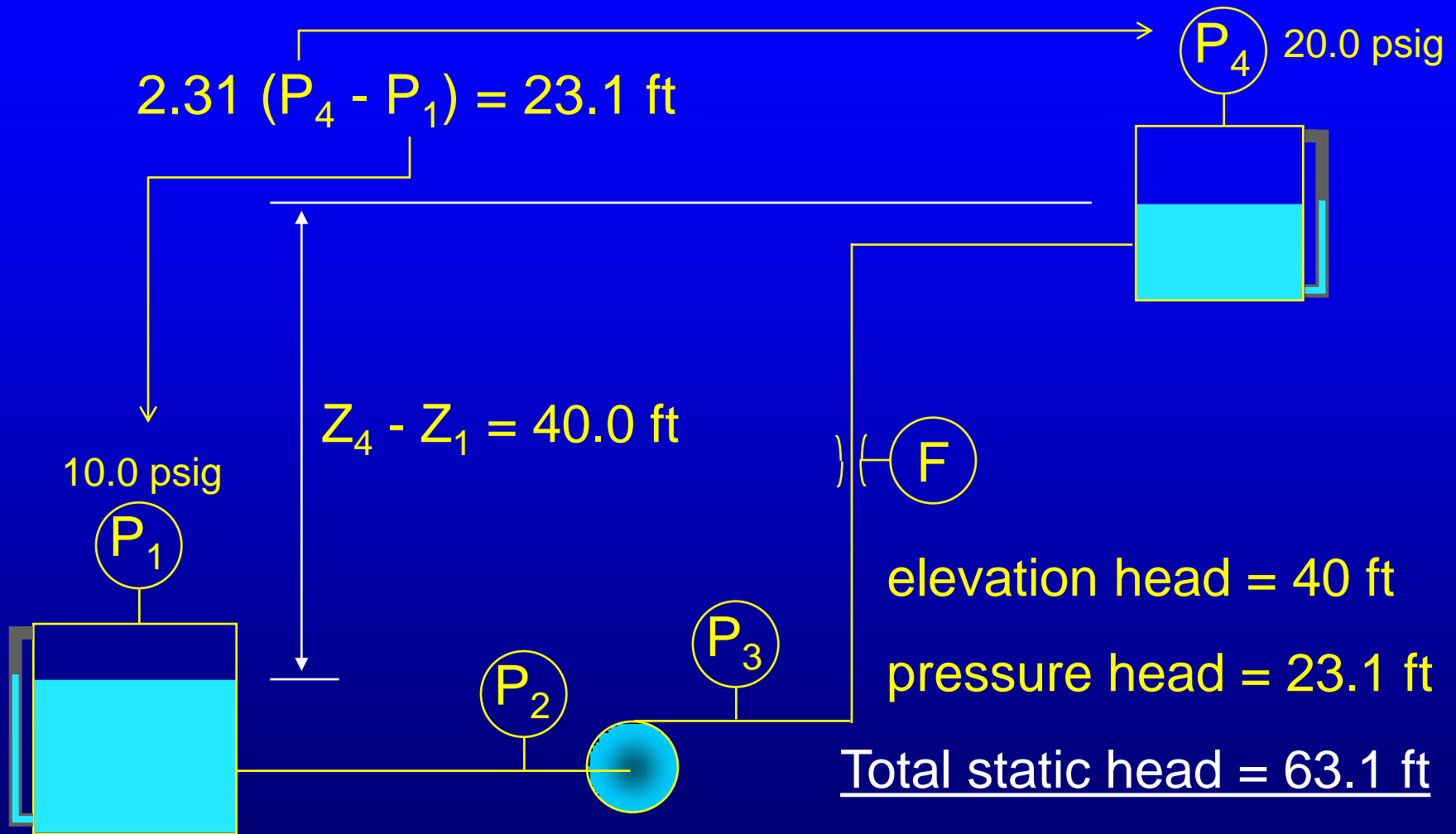
Butterfly Valve 35% to 40 % Open on Pump Discharge



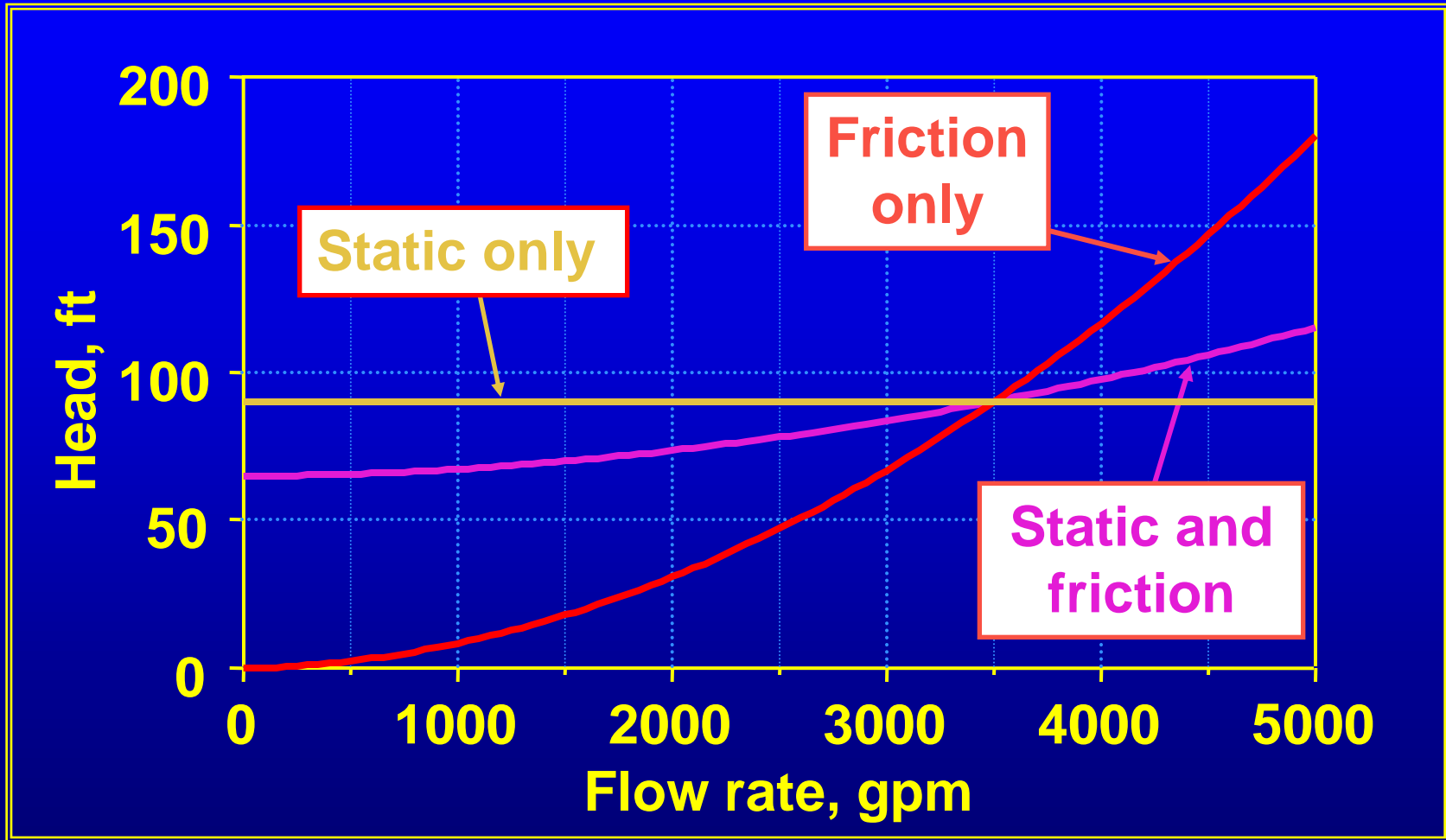
System curves are made up of two fundamental components - the static head and the frictional head



Estimating the static head for a system

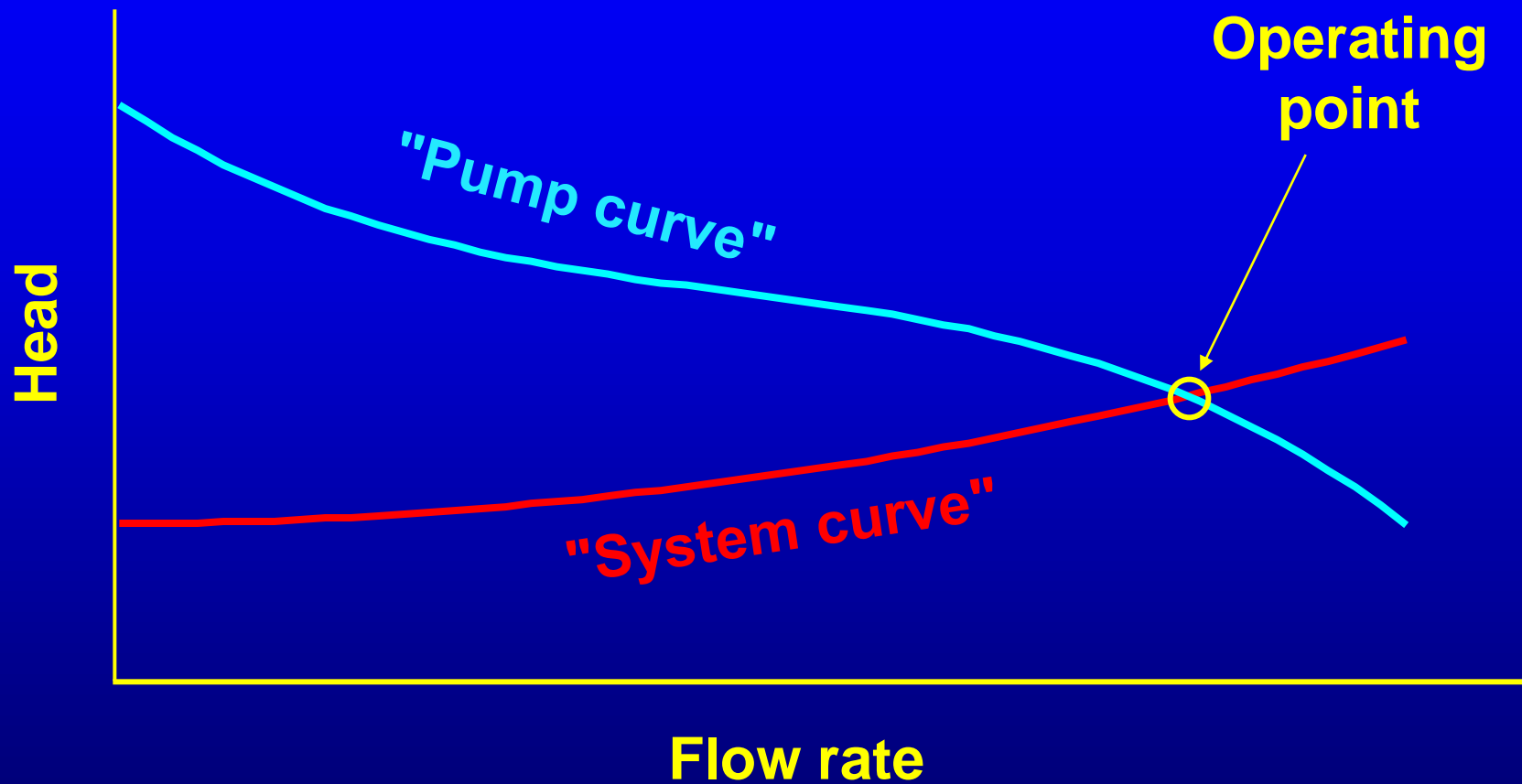


System head curves for all frictional, all static, and combined static and frictional systems



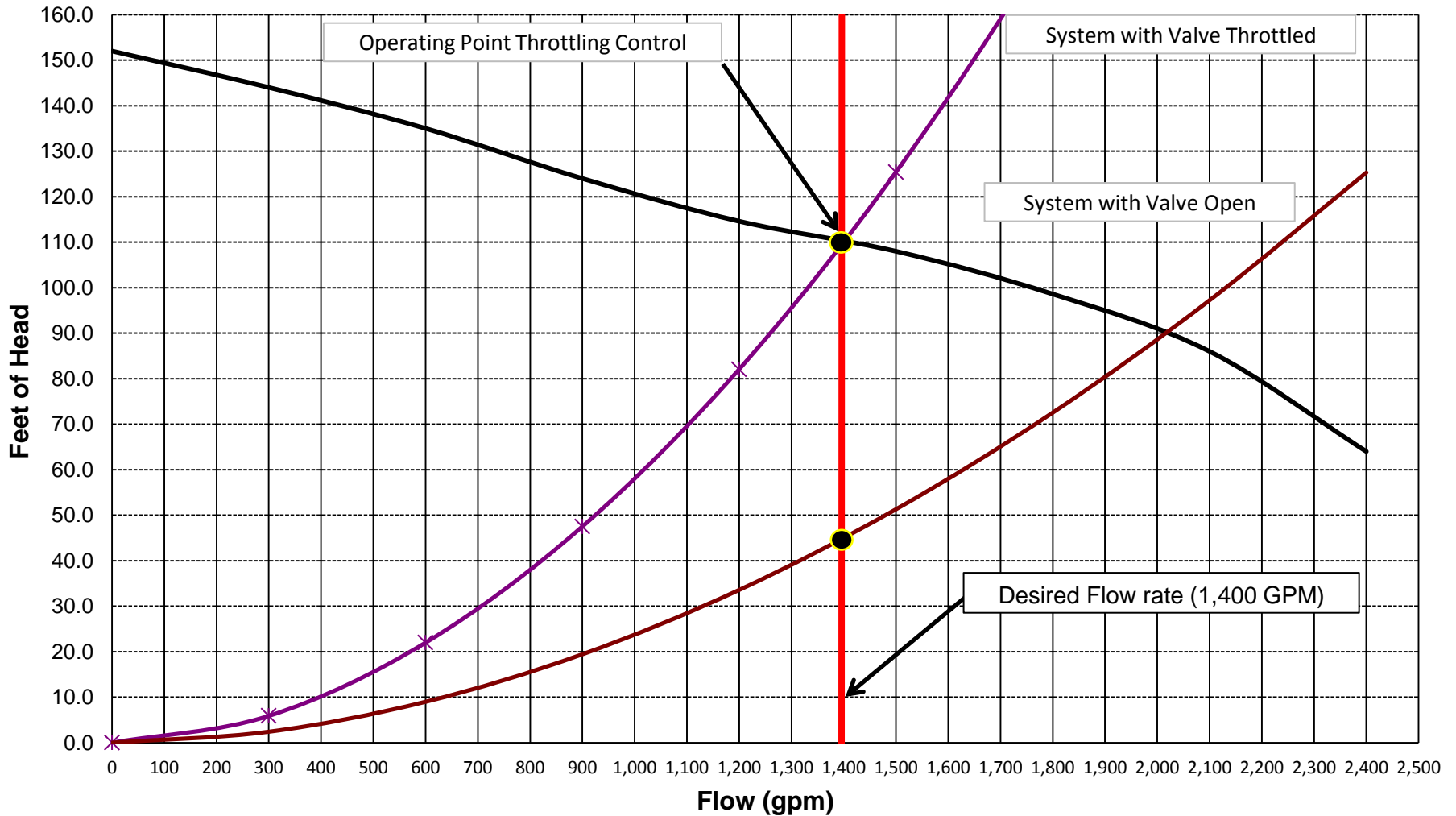
NOTE: These are three different systems

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



Affect of Throttling Valve

Pump System Requirements



Pump Horsepower Calculation

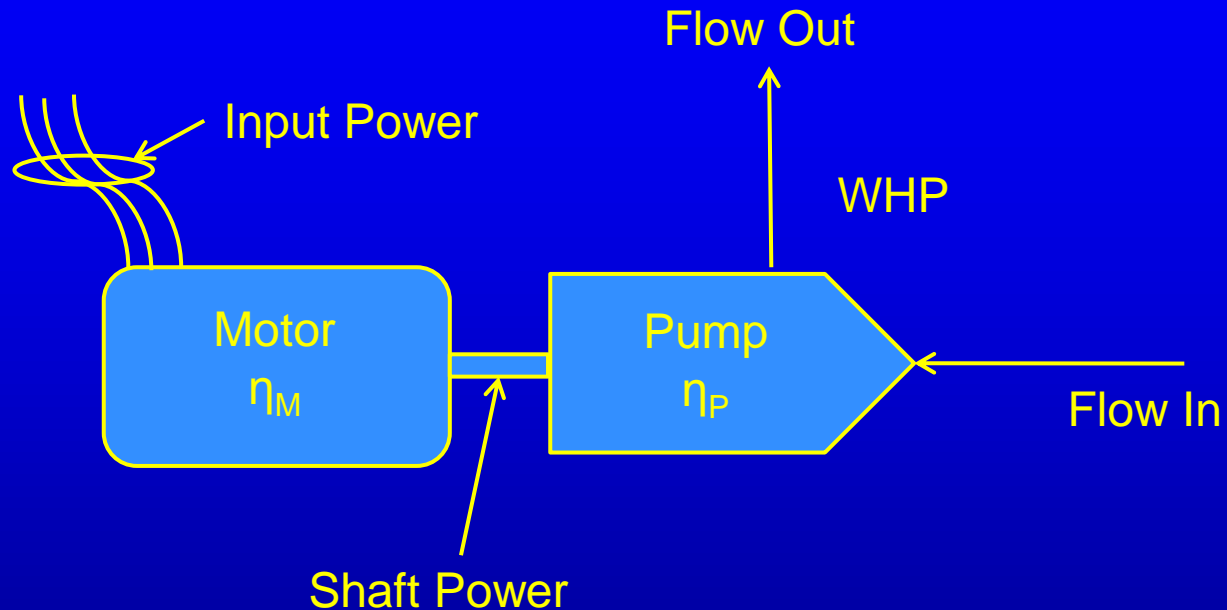
$$\text{Input Power (HP)} = (\text{WHP}) / (\eta_M * \eta_P)$$

$$\text{WHP} = \frac{\text{Flow (GPM)} * \text{Head (Ft)} * (\text{S.G.})}{3960}$$

η_M = motor efficiency and η_P = pump efficiency

S.G. = Specific Gravity (normally assumed as 1 for water)

Pumping Power Diagram

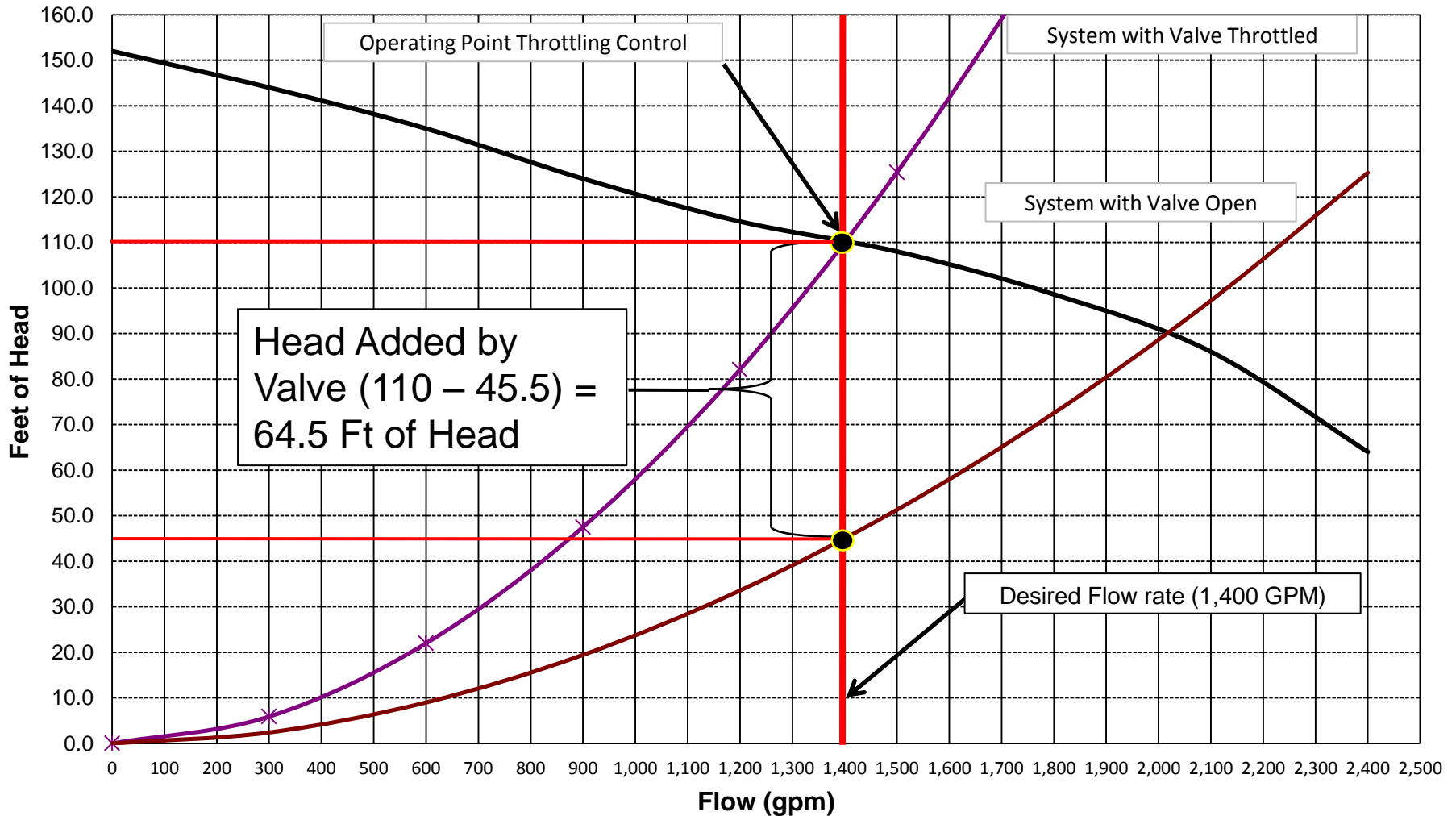


$$\text{Shaft Power} = \text{Input Power} * (\eta_M)$$

$$\text{WHP} = \text{Shaft Power} * (\eta_P)$$

Affect of Throttling Valve

Pump System Requirements



Pump Horsepower Calculation

Consider the preceding graph:

Assume: $\eta_M = 0.9$ and $\eta_P = 0.75$

Throttled Pump:

$$\text{Electric Consumption} = \frac{1400 * 110}{3960(0.9)(0.75)} = 57.61 \text{ HP} = 42.96 \text{ kW}$$

Slower Speed or Trimmed Impeller:

$$\text{Electric Consumption} = \frac{1400 * 45.5}{3960(0.9)(0.75)} = 23.83 \text{ HP} = 17.77 \text{ kW}$$

Throttle Valve Energy Waste = **33.78 HP or 25.19 kW**

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

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

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

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

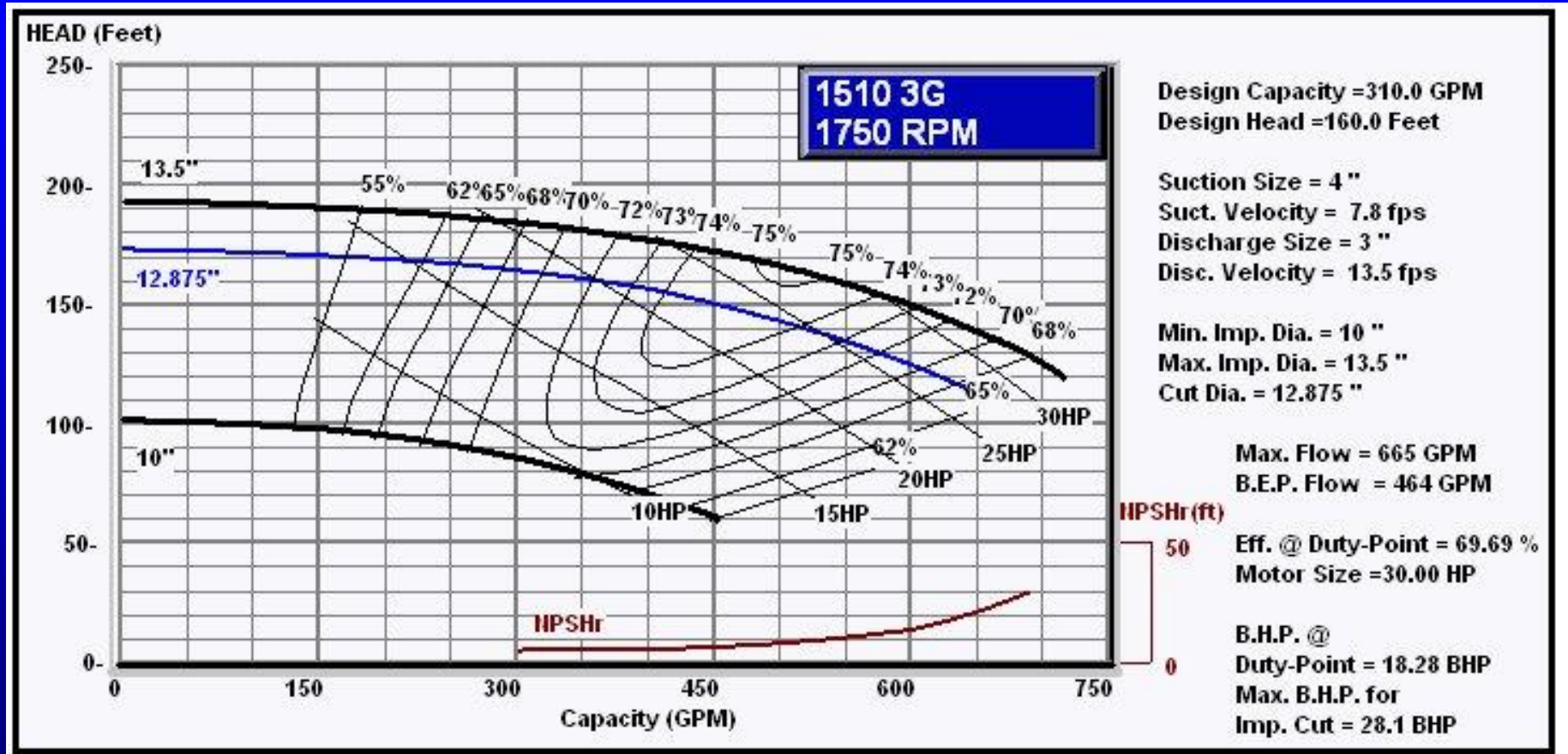
$$\left(\frac{Q_1}{Q_2}\right) = \left(\frac{D_1}{D_2}\right)^1$$

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

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

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

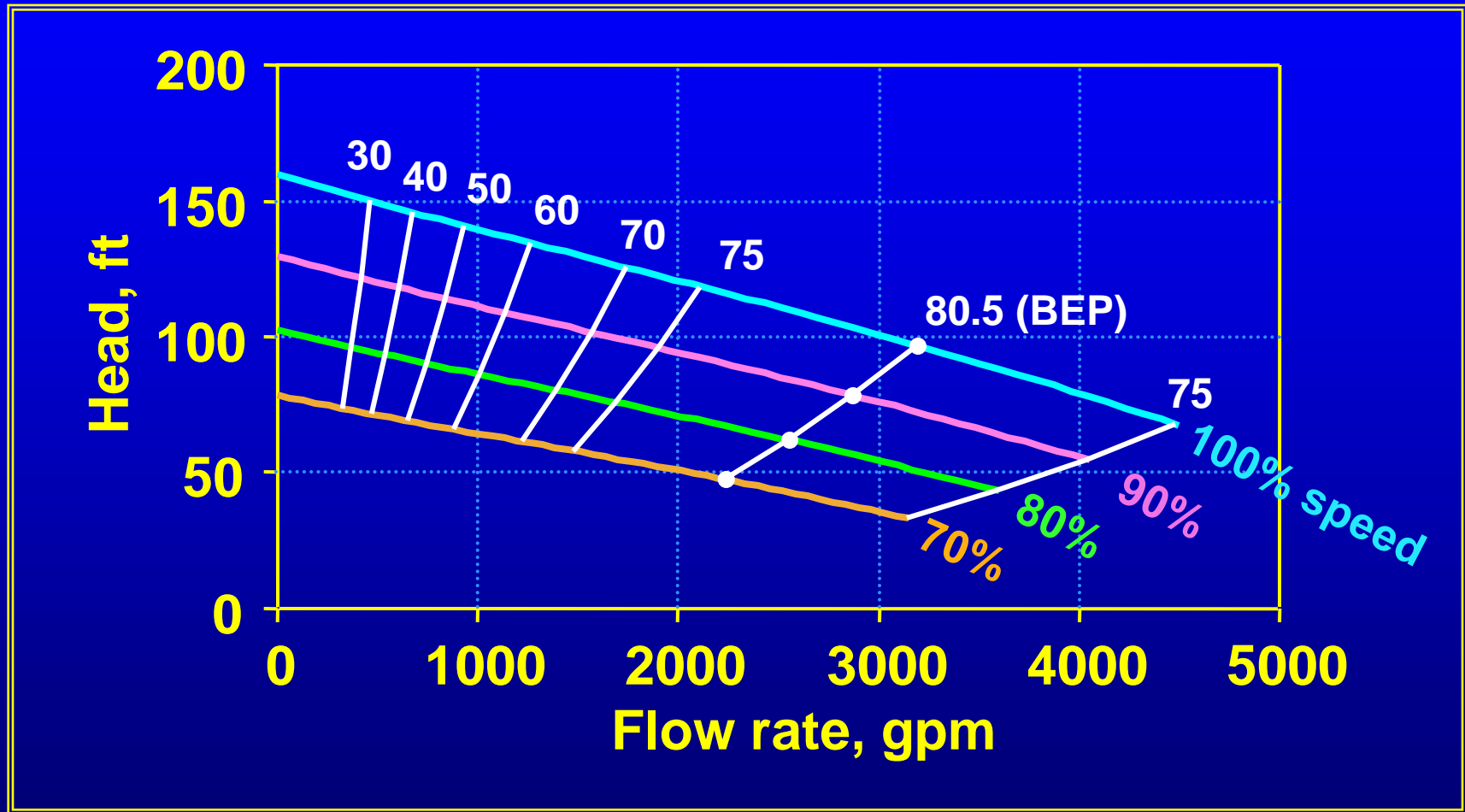
The size of the Pump Curve decreases with smaller impellers



Variable speed drive performance characteristics

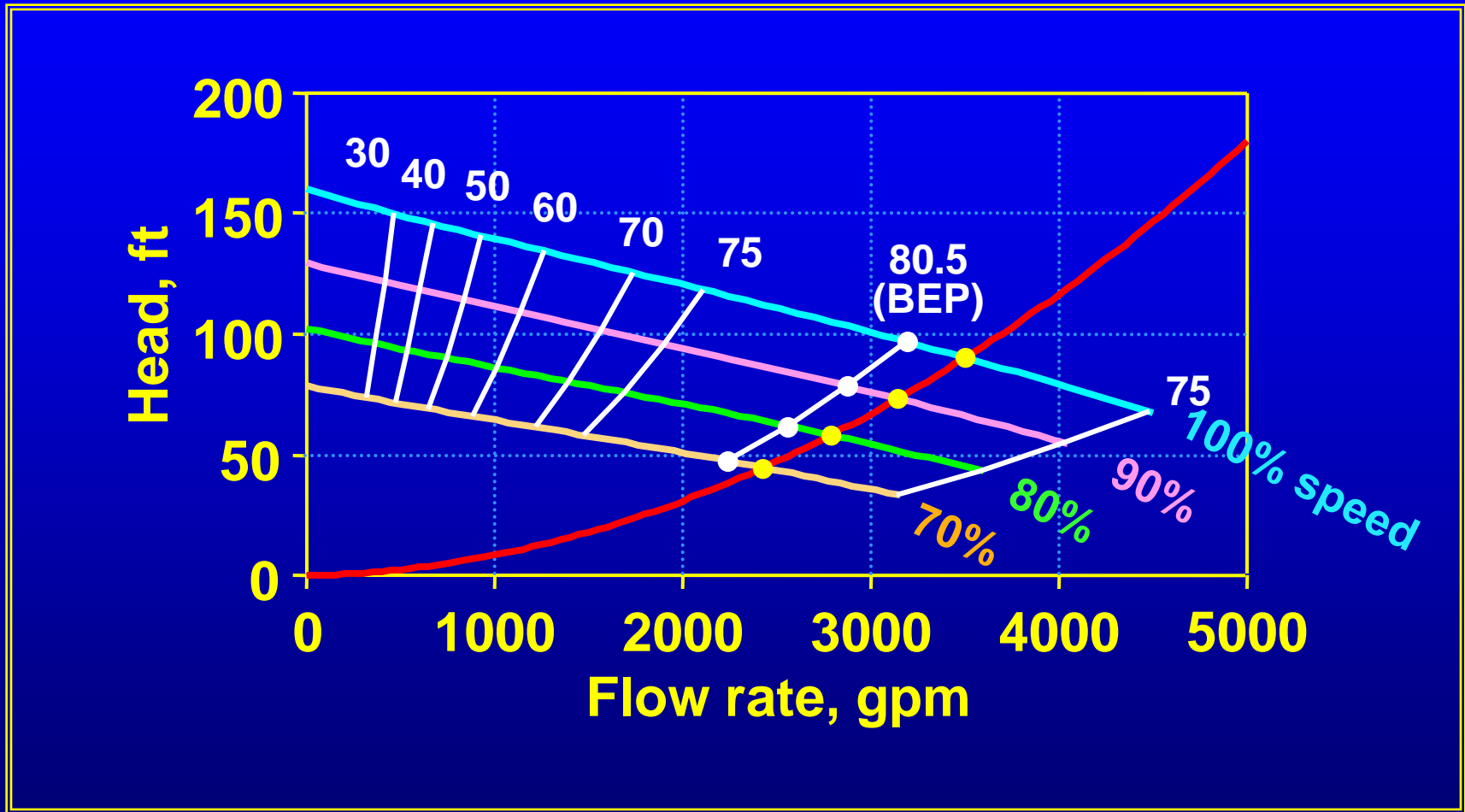


Speed is another matter - the affinity laws generally hold up very well with speed changes

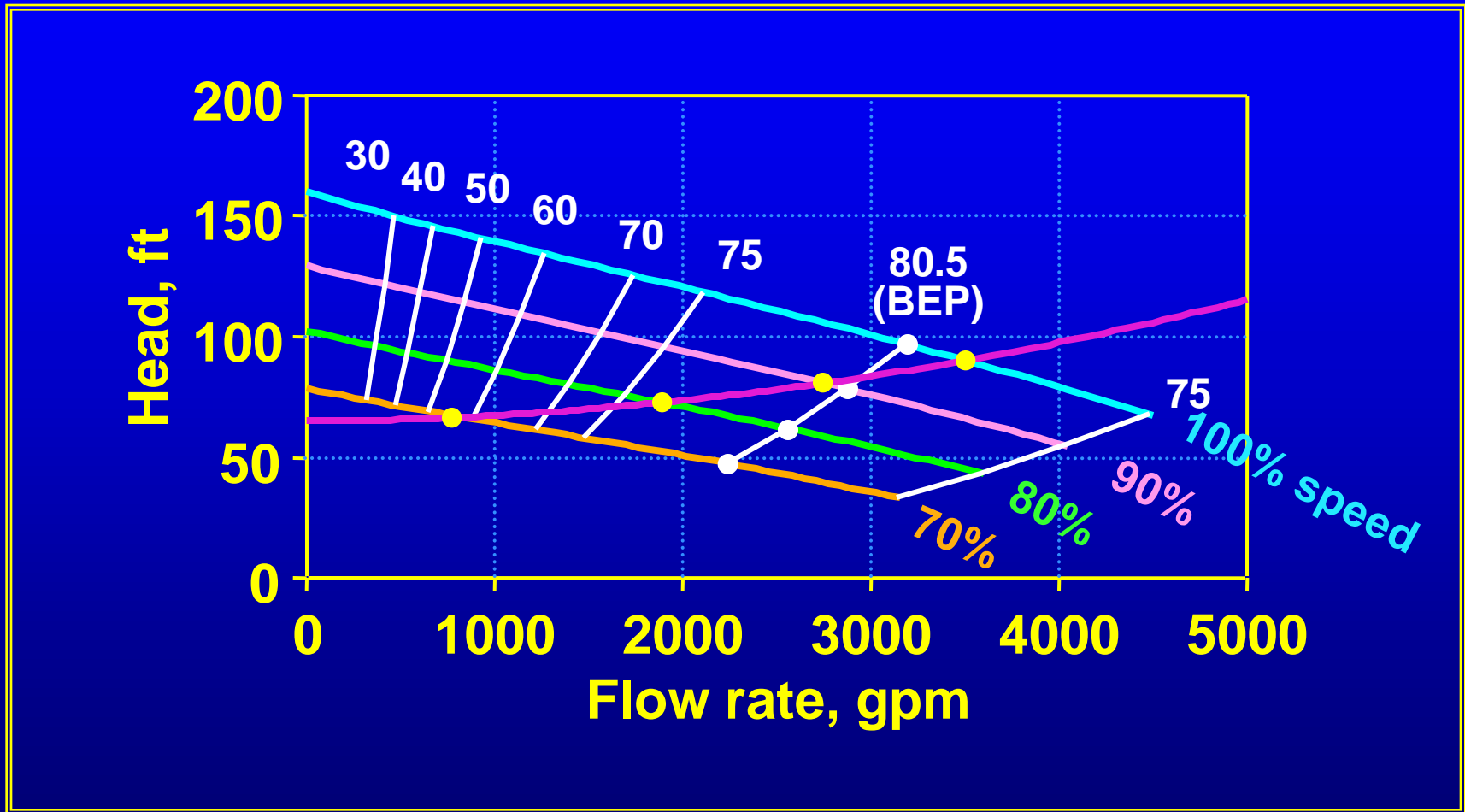


What happens if we reduce pump speed in the three systems types mentioned earlier?

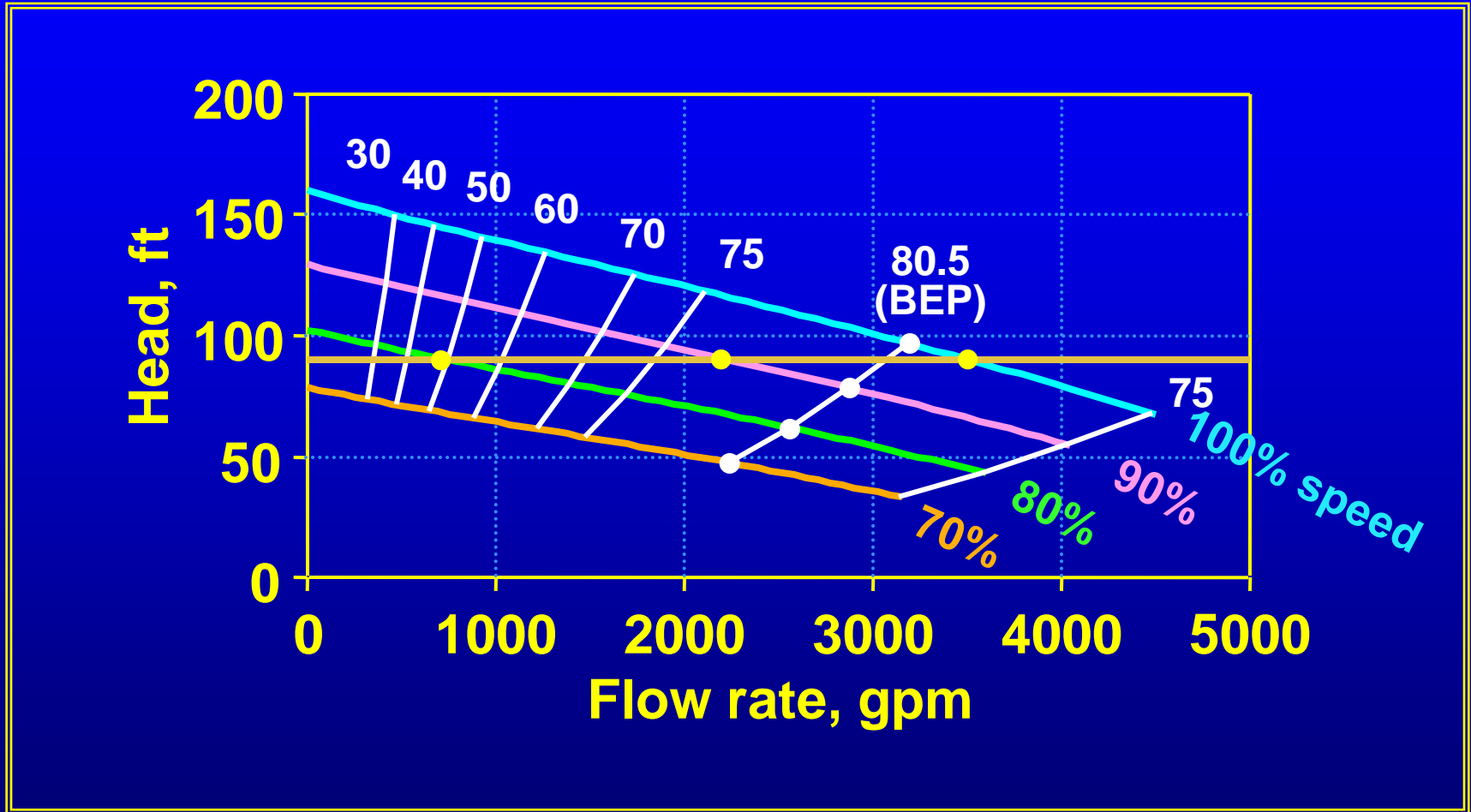
Change in speed for the all frictional system results in maintenance of constant pump efficiency



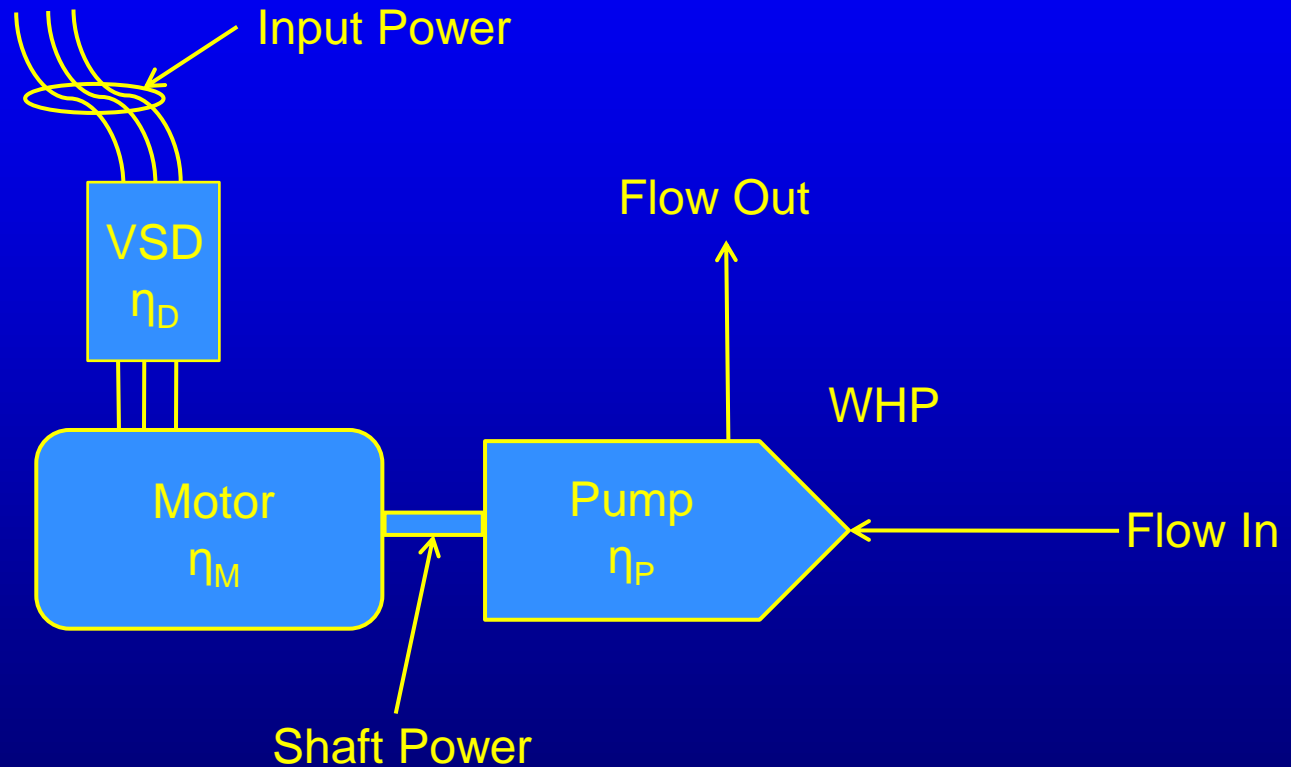
In a system with static head, pump efficiency does *not* remain fixed as speed changes



In a system with **ONLY** static head, the effect is even more dramatic



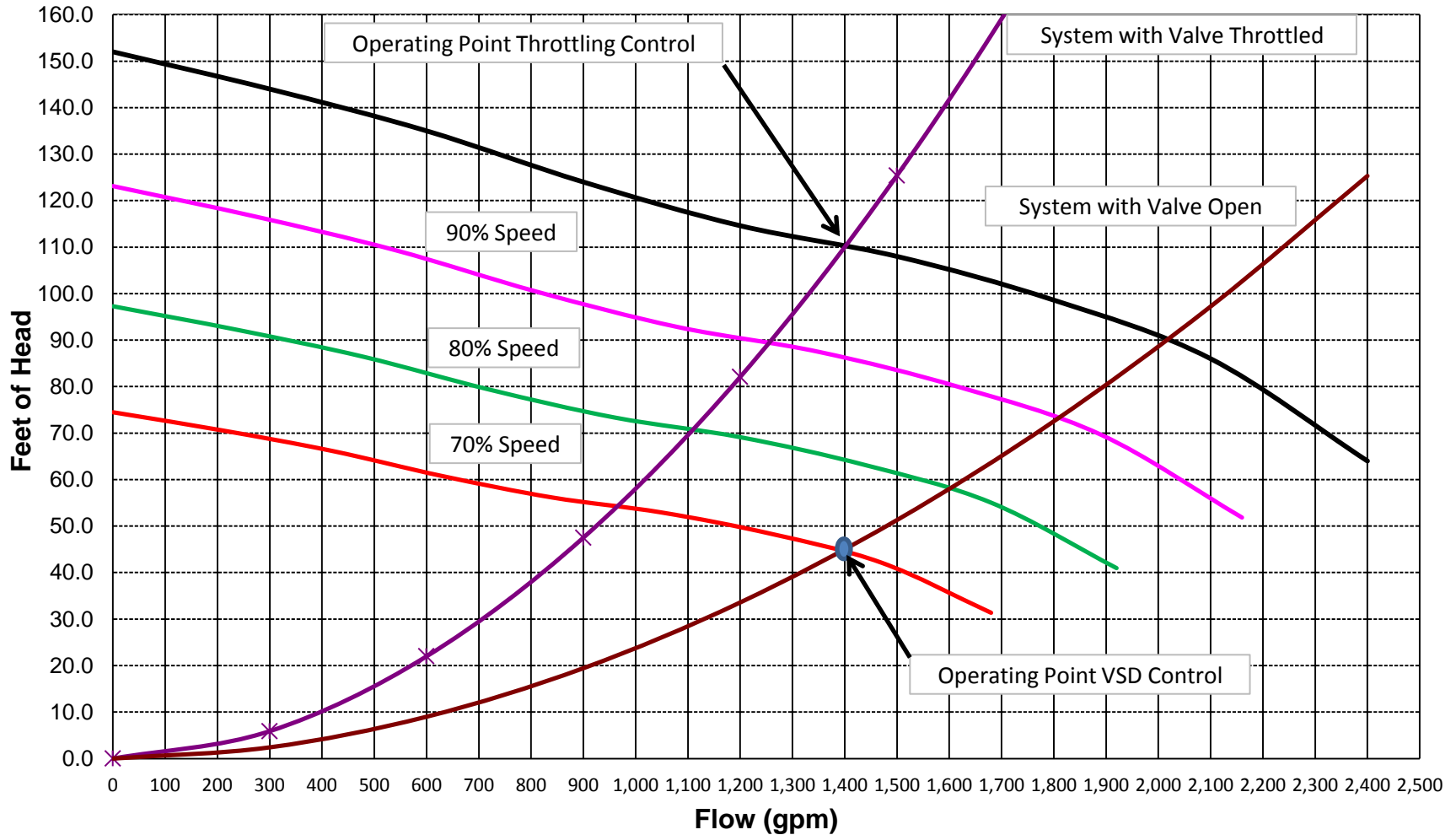
VSD on Pump Motor



$$\text{Input Power} = \text{WHP} / (\eta_D * \eta_M * \eta_P)$$

Actual Pump Data for VSD Operation

Variable Speed Pumping



One of Schneider's Parts Washer Pumps with Throttled Discharge

Butterfly Valve 35% to 40 % Open on Pump Discharge



Pumping System Assessment Tool (PSAT)

Condition A

End suction ANSI/API

Pump rpm: 1780

Drive: Direct drive

Units: gpm, ft, hp

Kinematic viscosity (cS): 1.00

Specific gravity: 1.000

stages: 1

Fixed specific speed? **YES**

Line freq.: 60 Hz

HP: 20

Motor rpm: 1780

Eff. class: Average

Voltage: 460

Estimate FLA

Full-load amps: 24.2

Size margin, %: 0

Operating fraction: 1.000

\$/kwhr: 0.0580

Flow rate, gpm: 1200

Head tool: Head, ft: 32.7

Load estim. method: Current

Motor amps: 16.2

Voltage: 466

Retrieve defaults | Set defaults | Copy A > to B >

System curve tool: select below

Condition B

End suction ANSI/API

Pump rpm: 1509

Drive: Direct drive

Units: gpm, ft, hp

Kinematic viscosity (cS): 1.00

Specific gravity: 1.000

stages: 1

Fixed specific speed? **YES**

Line freq.: 60 Hz

HP: 20

Motor rpm: 1509

Eff. class: Average

Voltage: 460

Estimate FLA

Full-load amps: 24.2

Size margin, %: 0

Operating fraction: 1.000

\$/kwhr: 0.0580

Flow rate, gpm: 1200

Head tool: Head, ft: 23.5

Load estim. method: Current

Motor amps: 13.3

Voltage: 466

Copy B < to A <

Background information

STOP

	Condition A			Condition B		
	Existing	Optimal	Units	Existing	Optimal	Units
Pump efficiency	80.0	84.6	%	78.7	84.2	%
Motor rated power	20	15	hp	20	10	hp
Motor shaft power	12.4	11.7	hp	9.0	8.4	hp
Pump shaft power	12.4	11.7	hp	9.0	8.4	hp
Motor efficiency	90.9	92.2	%	89.7	91.1	%
Motor power factor	77.8	79.9	%	70.2	80.7	%
Motor current	16.2	14.7	amps	13.3	10.6	amps
Motor power	10.2	9.5	kW	7.5	6.9	kW
Annual energy	89.1	83.1	MWh	65.8	60.6	MWh
Annual cost	5.2	4.8	\$1000	3.8	3.5	\$1000

Annual savings potential, \$1,000: 0.3

Optimization rating, %: 93.3

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: System: Date: Application: Evaluator: General comments

Condition B Notes

Facility: System: Date: Application: Evaluator: General comments

Valve Tool

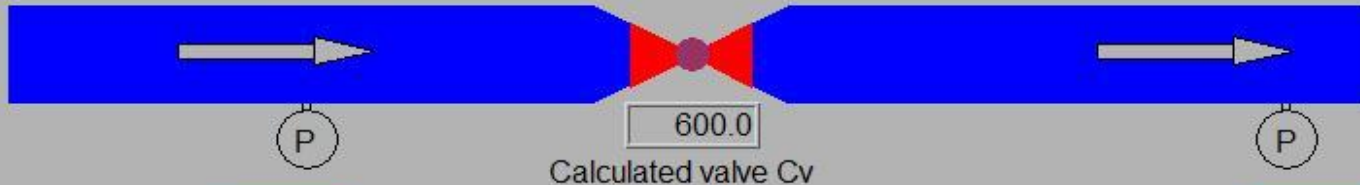
Units

Available data selector

Operating fraction	<input type="text" value="0.675"/>
Average electrical cost rate, \$/kWh	<input type="text" value="0.0580"/>
Pump efficiency, %	<input type="text" value="77.0"/>
Motor efficiency, %	<input type="text" value="90.0"/>
Head loss, ft	<input type="text" value="9.24"/>
Frictional power loss, hp	<input type="text" value="2.8"/>
Frictional electrical power, kW	<input type="text" value="3.0"/>
Annual cost of friction, \$	<input type="text" value="1034"/>

Specific gravity

Specified flow rate, gpm



Upstream pressure, psig

Downstream pressure, psig

Upstream pipe ID, inches

Valve size, inches

Downstream pipe ID, inches

Upstream gauge elev, ft

Downstream gauge elev, ft

Upstream gauge velocity, ft/s

Valve velocity, ft/s

Downstream gauge velocity, ft/s

Create new log

Retrieve log entry

K_reducer & expander

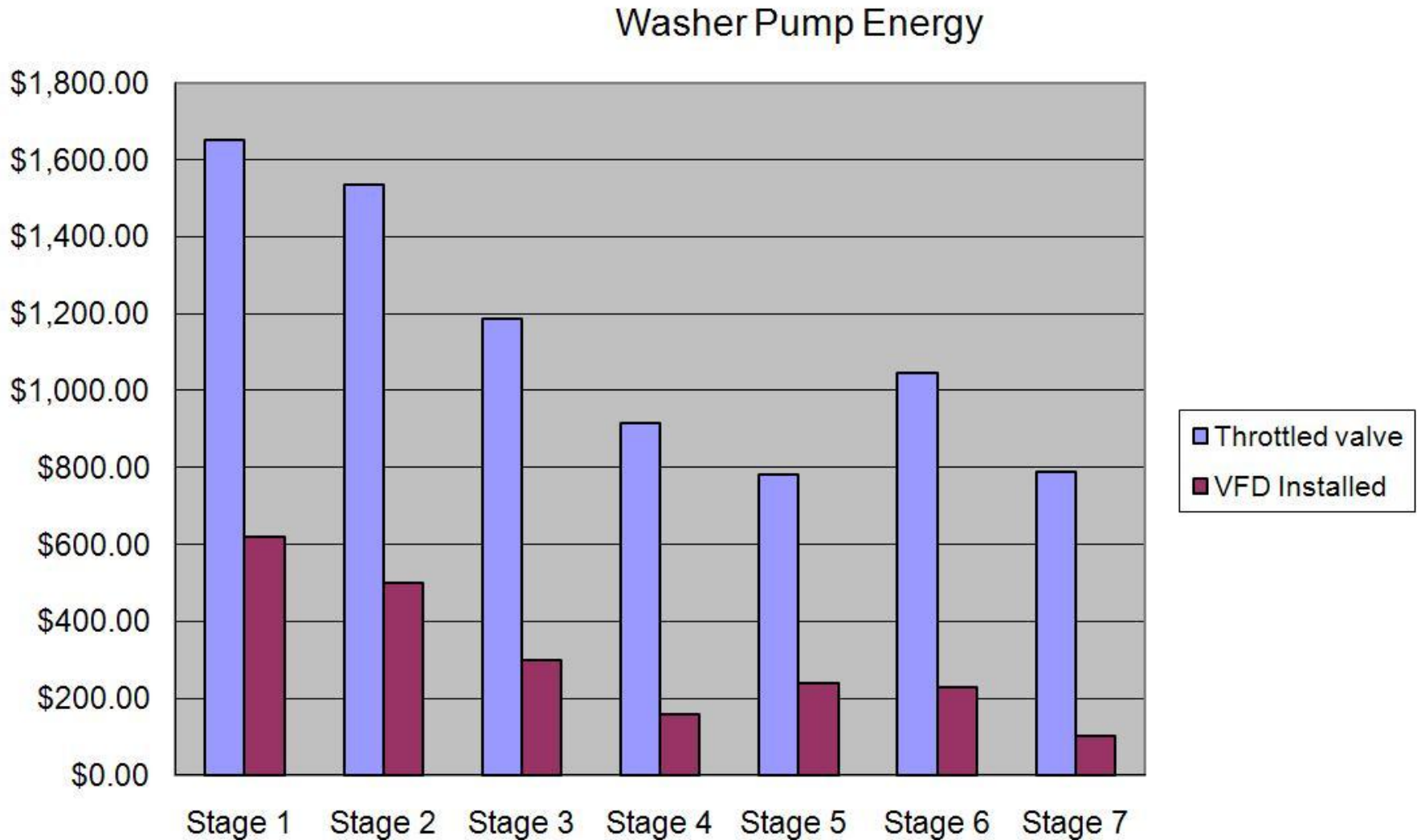
K_valve

K_total

Application and Copyright notice

STOP

Washer Has 7 Throttled Pumps!



Washer Has 7 Throttled Pumps!

Pump	Description of original equipment	Total material cost	Yearly \$ savings (from VFD installation sheet)	ROI in years
1	20hp pump w/ discharge closed @ 50%	\$892.67	\$1,034.13	0.86
2	20hp pump w/ discharge closed @ 50%	\$892.67	\$1,037.68	0.86
3	15hp pump w/ discharge closed @ 50%	\$662.66	\$885.91	0.75
4	10hp pump w/ discharge closed @ 50%	\$624.14	\$756.68	0.82
5	10hp pump w/ discharge closed @ 50%	\$624.14	\$540.12	1.16
6	10hp pump w/ discharge closed @ 50%	\$624.14	\$815.93	0.76
7	7.5hp pump w/ discharge closed @ 50%	\$624.14	\$689.93	0.90
Totals	92.5hp	\$4,944.60	\$5,760.38	0.86

Other Realized Advantages

- Replaced old corroded gauges with advantageously placed pressure and flow gauges
- Staff no longer had to open the washer to check flow from nozzles
- Improved Safety
- Minimizes downtime
- Better quality and process control
- Eliminating use of valve provides ergonomic assistance

VSDs Company-wide!

- VSDs implemented in Seneca, S.C., two plants in Mexico, and soon to be installed in Lexington, KY
- New Entry in Schneider's Global Energy Best Practice Manual
- In addition to energy savings, also a potential marketing tool for VSD products

Advantages for TTU IAC

- Continued experience with VSD recommendations
- Learning tool for emerging student assessors
- Shared results from Schneider utilized as example of energy and cost savings for future assessments

Conclusion

What you are doing can have a
GLOBAL IMPACT!

Thank You For Your Time

Questions?