Variable Speed Pumping in GTCC Power Plants

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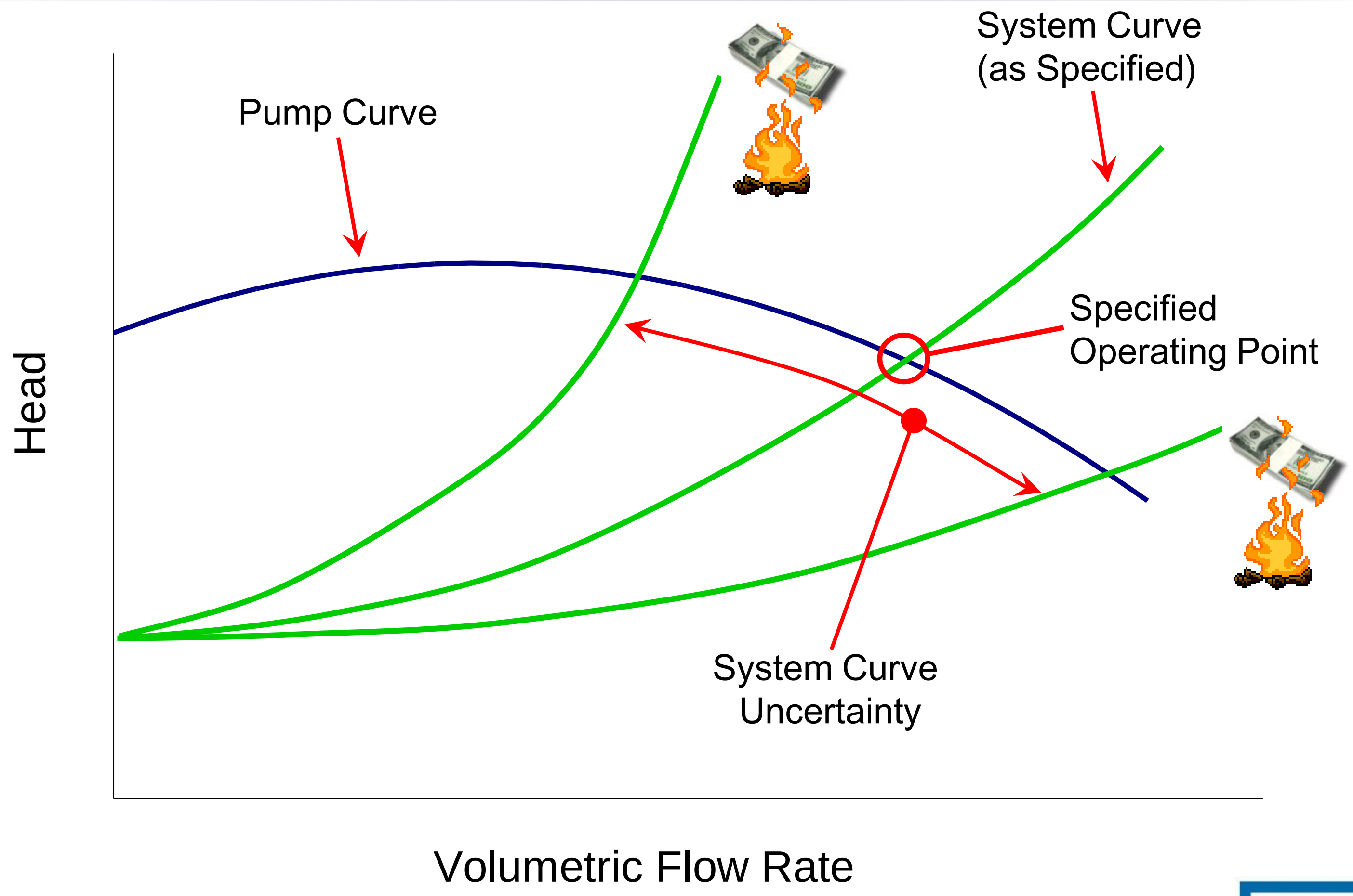
Fixed Speed vs. Variable Speed

Ability to control pump speed minimizes power use and provides better thermal efficiency

- **Variable frequency drive (VFD)**
  - Most common method
  - Provide accurate speed and torque control of the electric motor without added drive train length
- **Fluid drives and fluid couplings**
  - Similar advantages of low starting torque and variable speed control
  - Loss of system efficiency due to slippage across the fluid drive/coupling

System Curve Uncertainty Results in Uncertain Pump Operation – and Higher Costs



Variable Speed Pumping

- **Why use a variable speed pump?**

In most cases the variable speed drive does an excellent job at replacing antiquated, wasteful, and sometimes detrimental means of pump control.

- **When to use variable speed?**

There are some cases where other methods of pump output control could be implemented more economically than by using a variable speed drive. Even though there are over 150 manufacturers of variable speed drives and the prices have made them relatively inexpensive.

- **When not to use variable speed?**

There are some systems where an even less costly but more effective means of pump performance control can be used.

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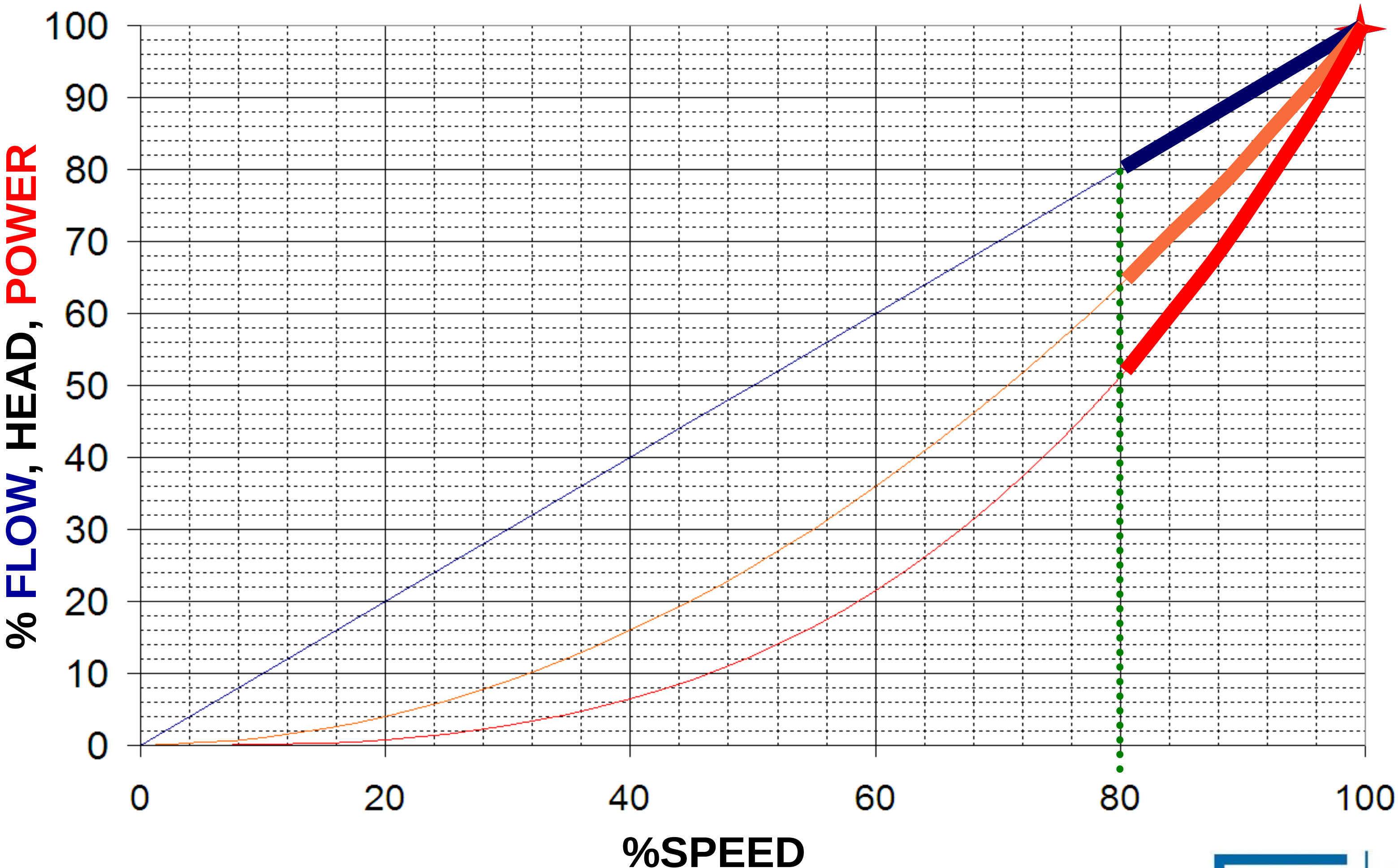
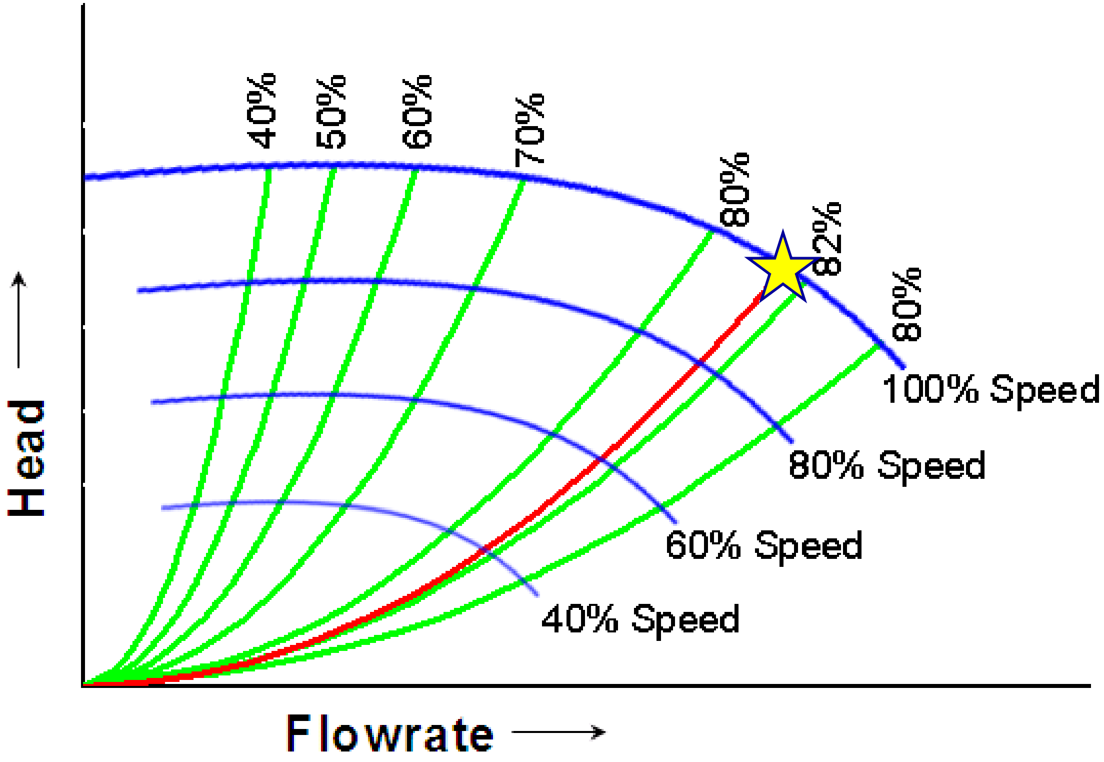
Why use a Variable Speed Pump?

- Take advantage of the affinity rules of Centrifugal Pumps.



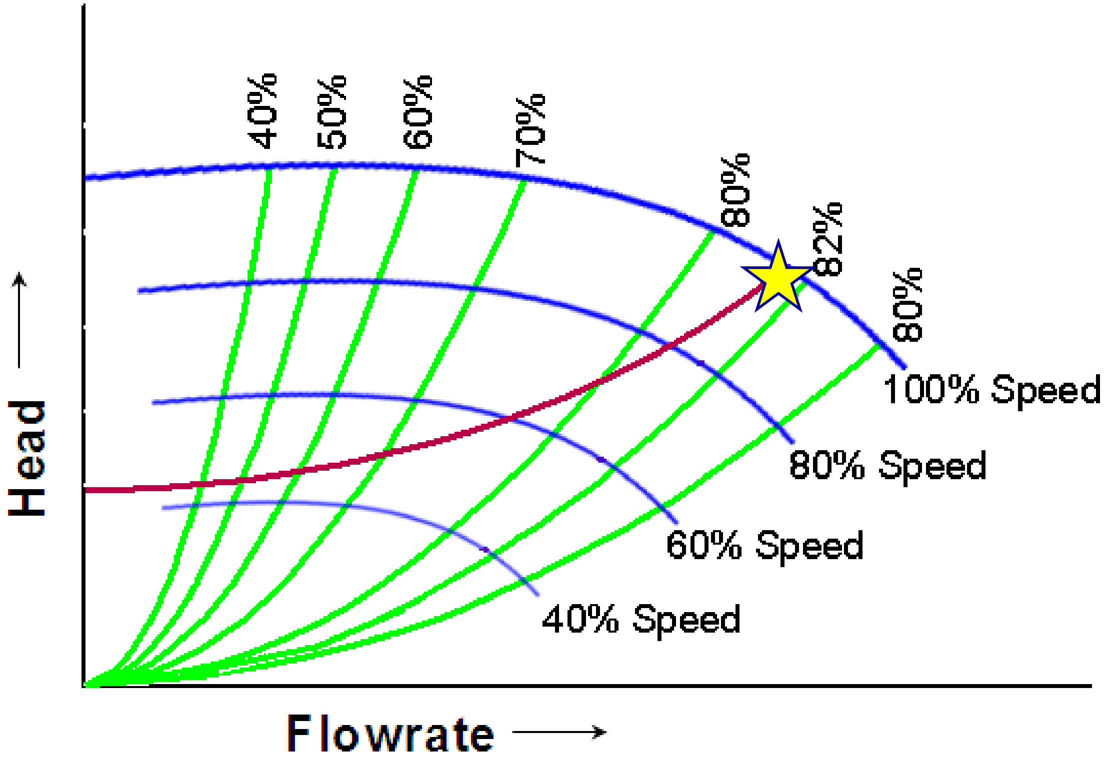
Pump Speed Changes
Boiler Feed

Friction-Dominated Systems



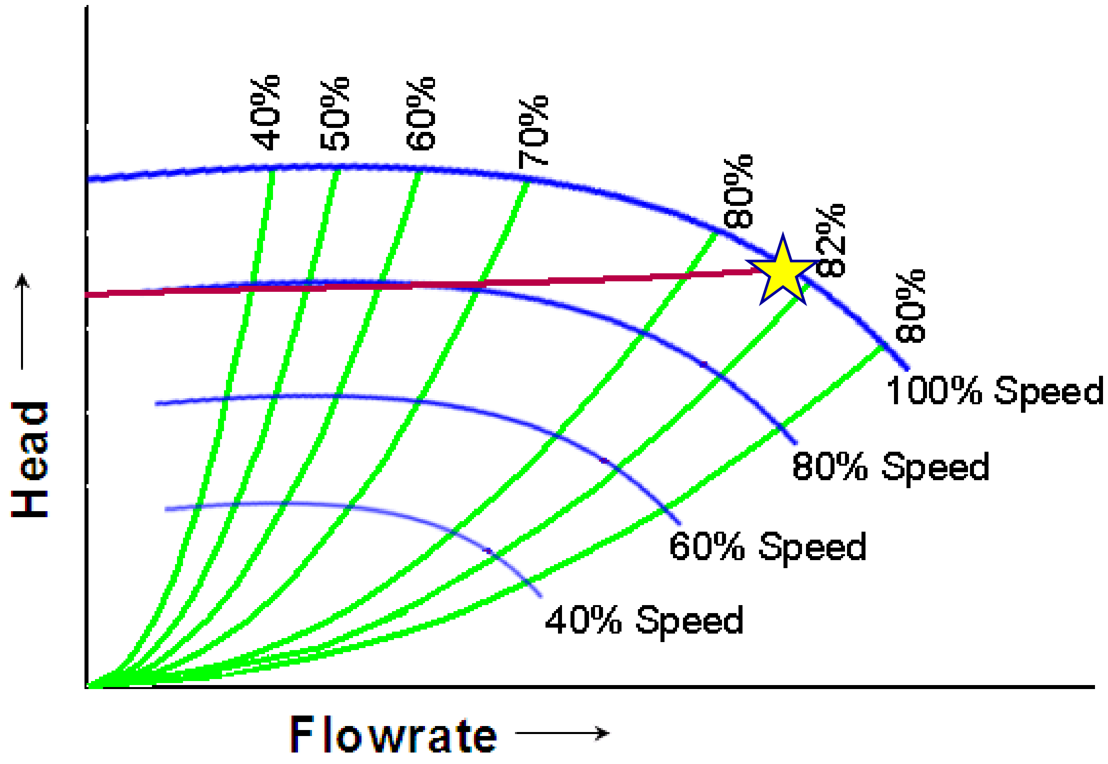
Pump Speed Changes

Mixed Friction-Static Systems



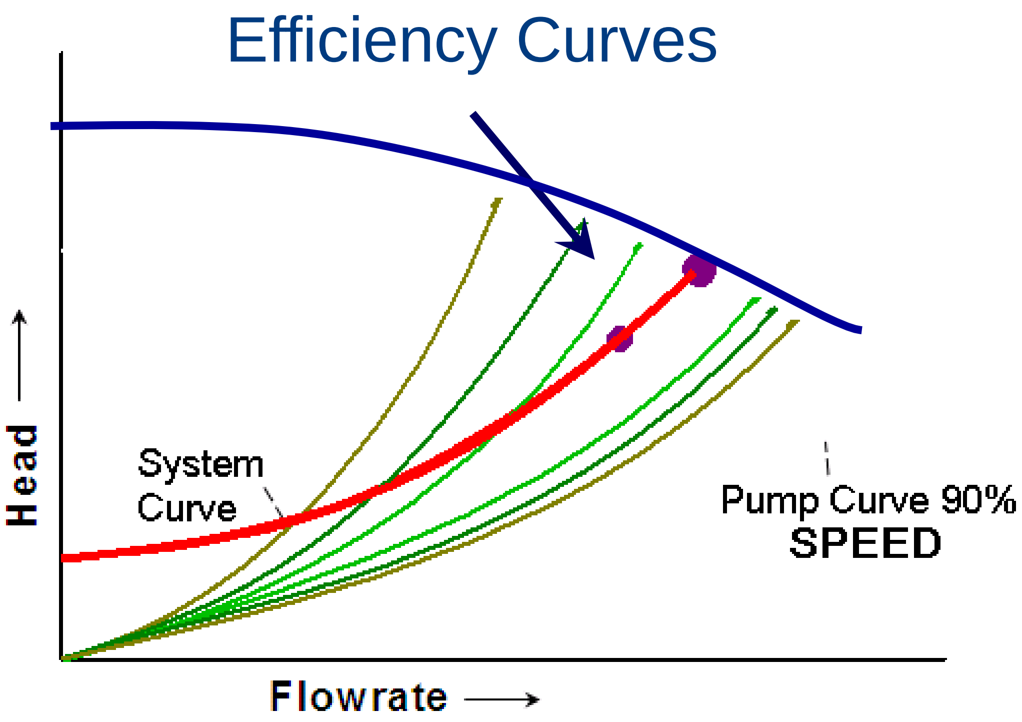
Pump Speed Changes

Static-Dominated Systems

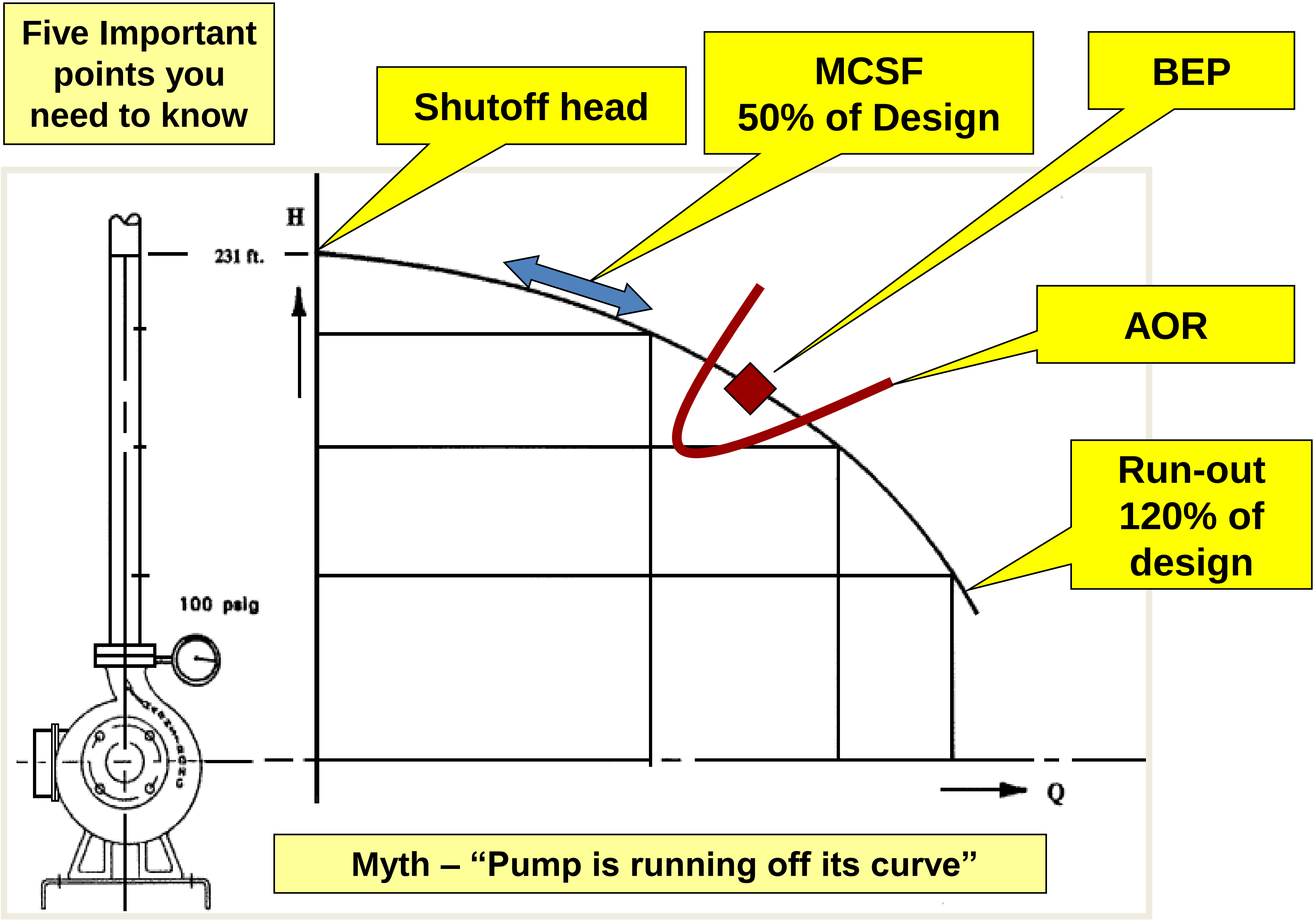


Pump Speed Changes

- **Using the affinity rules the pump head curve can be adjusted for a different SPEEDS.**



READING A PUMP CURVE



Power Plant Perspective
Heat Rate / Parasitic Load

$\varphi hr = H / E$

Where:

φhr = heat rate (Btu/kW, kJ/kW)
H = heat supplied to the power plant for a period (Btu, kJ)
E = energy output from the power plant in the period (kWh)

Heat rate can be improved by reducing energy losses and improving motor driven equipment efficiency.

Variable Speed Boiler Feed Service

Boiler feed pumps:

Variables that Impact Boiler Feed Pump Selection

Hot Standby

- Allows the plant to react quickly to load demand, reaching full load within 10 minutes
- Minimum flow/minimum continuous stable flow:
  - Boiler feed pump capable of continuous operation at recirculation flow rate during hot standby operation
- Minimum flow line (size):
  - Line sized to continuously handle recirculation flow rate during cold start-up and hot standby mode

Load Swings

- Pumps should be selected to meet the different load points the plant will operate at throughout its 24-hour cycle

Power Plant Perspective
Boiler Feed Pumps

- The boiler feed pumps consume a large fraction of the auxiliary power used internally within a power plant.

- If a unit cycles frequently then operation of the pumps with VFD's will offer the best results on heat rate reductions, followed by fluid couplings.

- The use of VFD's for boiler feed pumps is becoming more common in the industry for larger units.

- And with the advancements in LP steam turbines, a motor-driven feed pump can actually improve the thermal performance of a system up to the 600-MW range versus turbine drive pumps.

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Condensate Pump Service

Condensate pump VSD considerations:

- the suction side of the discharge head is vented back to the top of the condenser
- Variables that impact condensate pump selection include:

Load swings

Hot standby

Cold start

Starts and stops

Pump sizing

(3 pumps at 50% capacity vs. 2 pumps at 100% capacity)

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Variable Speed Heater Drain Service

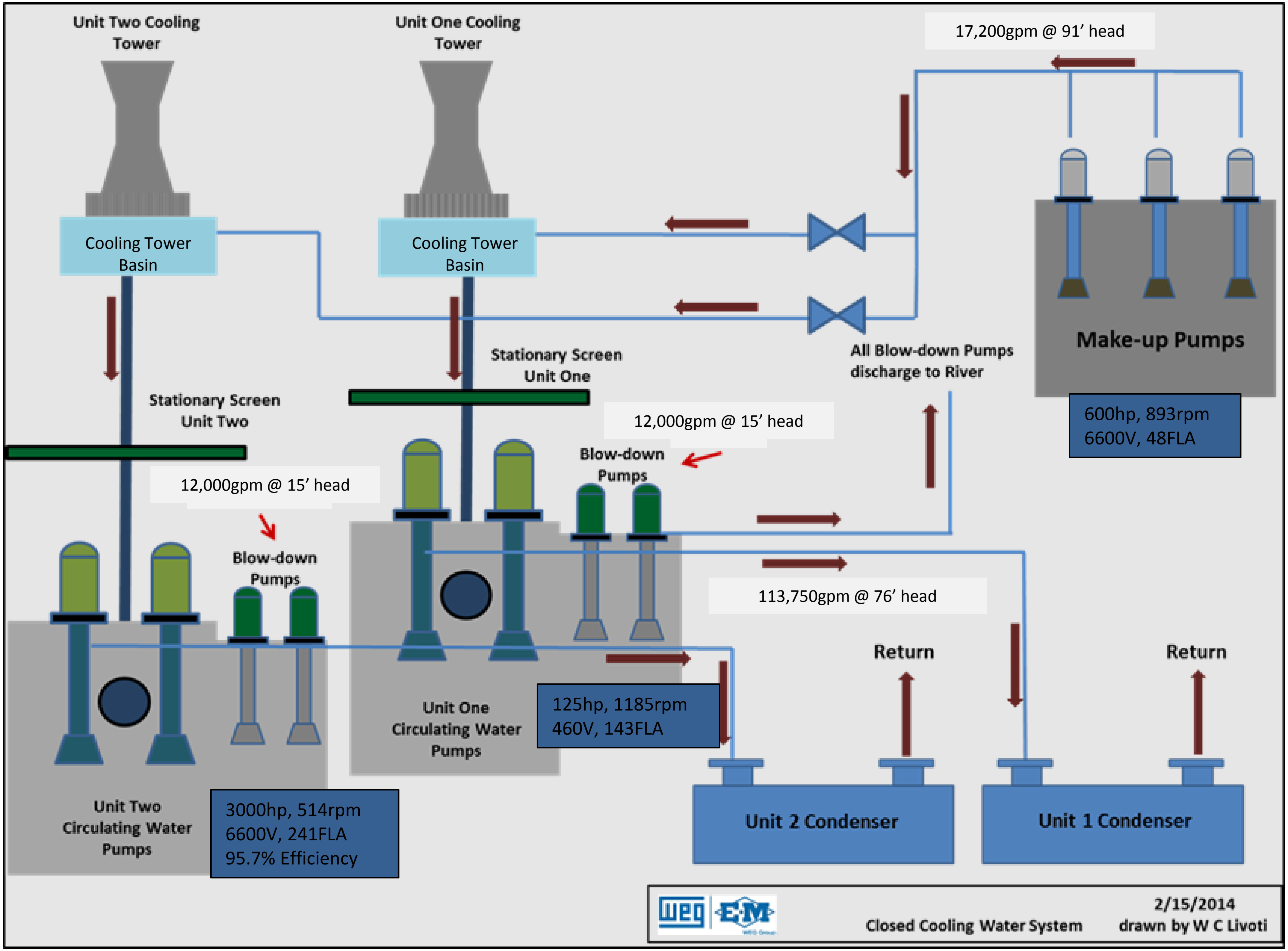
Heater Drain Pumps:

Condensate from the closed heaters is cascaded from the heater drain to the steam space of a lower-pressure heater where it flashes to steam

The condensate in the heater drain is pumped back into the feedwater cycle

In an open feedwater cycle, the drains from heaters located beyond the deaerator are cascaded back to the deaerator

Closed Loop Cooling Water Flow Diagram



Cost of Friction

Flow required	2500 gpm	2500 gpm	2500 gpm	2500 gpm
Head required	1000 feet	800 feet	1000 feet	1000 feet
Additional system friction loss	200 ft	0 ft	200 ft	200 ft
Motor eff	94%	94%	94%	96%
VFD efficiency factor	100%	98%	100%	100%
Mechanical drive eff	100%	100%	100%	100%
Pump eff	65%	88%	70%	65%
Energy cost per kWh	$0.05	$0.05	$0.05	$0.05
Operating hours per year	2000	2000	2000	2000
Factor	Base	Reduce friction by 200 feet.	Increase pump efficiency by 5 points.	Increase motor efficiency by 2 points.
System efficiency	51%	81%	55%	52%
System input power required for process	1033.2 bhp	623.0 bhp	959.4 bhp	1011.7 bhp
Power required for additional friction	206.6 bhp	0.0 bhp	191.9 bhp	202.3 bhp
Total power required	1239.9 bhp	623.0 bhp	1151.3 bhp	1214.1 bhp
Total cost per year	$92,496	$46,477	$85,889	$90,569
Cost Savings		$46,019	$6,607	$1,927

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Summary

- What is the cost of operating the pumping systems in their existing state:
    - Energy / efficiency
    - Maintenance
    - Production
- How are the pumps operating with respect to their Best Efficiency Points (BEP)
- Identify potential savings strategies applicable to the existing pumping systems
    - Heat Rate
    - Parasitic Load
    - Maintenance
    - Reliability
- Detail out as accurately as possible the cost of operation in the pumping system's optimized state
    - Uptime, Availability, Reliability, Efficiency
- Develop solutions / recommendations with options, prepare road map for implementation
- Provide technical support during implementation
- Track results, document savings, present savings to management

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Thank You