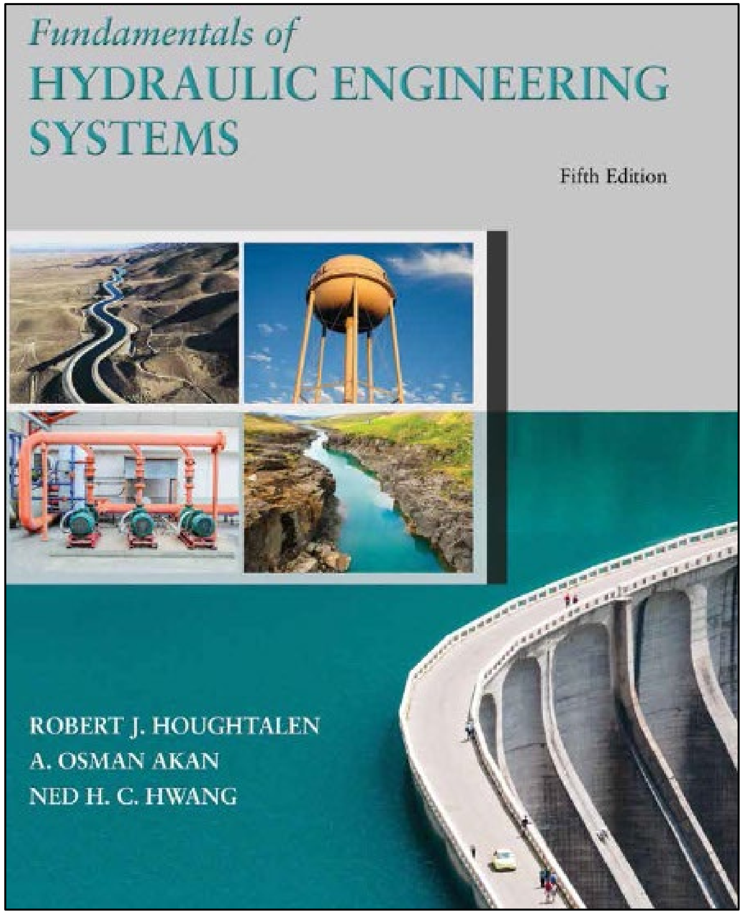
Fundamentals of Hydraulic Engineering Systems

Fifth Edition



Chapter 5c

Water Pumps

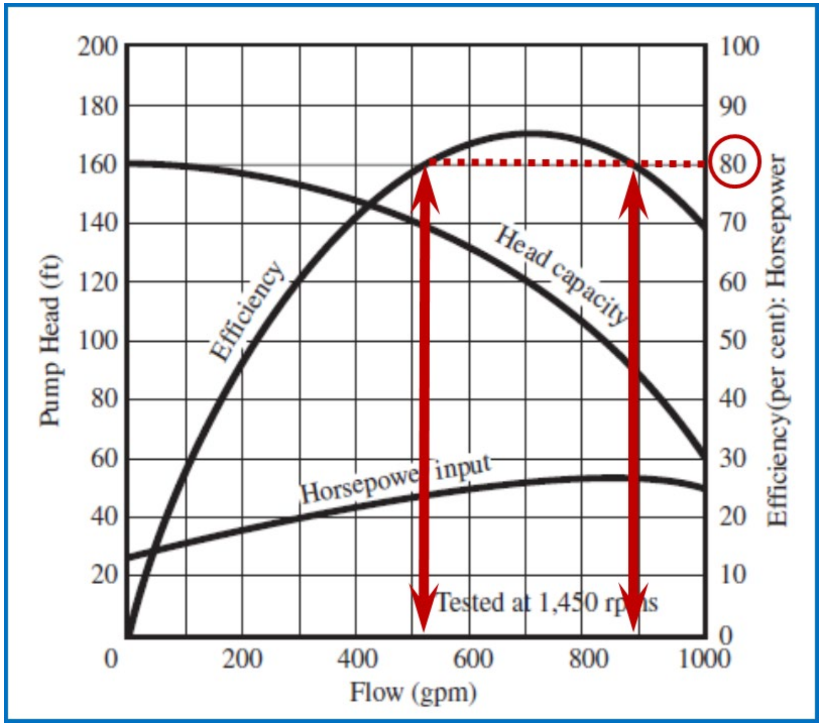
Pump Combinations – Large Flow Range (1 of 2)

Concepts and Visualization

Design Objective: Operate pumps at their peak efficiency.

Q: What is the flow range for operating this pump at an 80% or better efficiency?

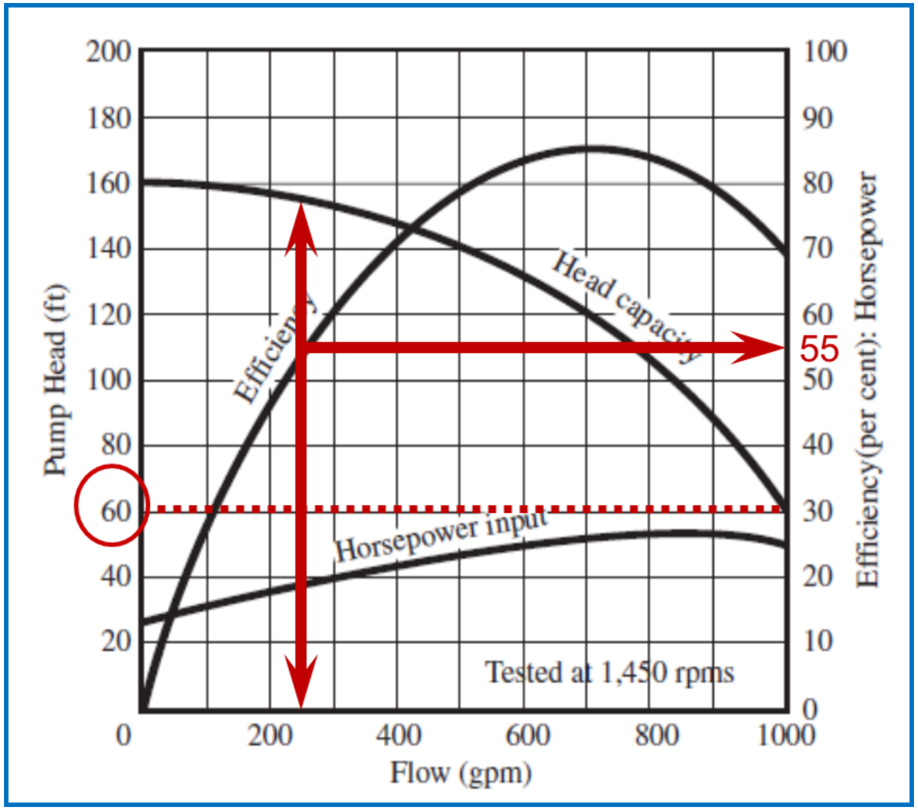
A: 520 to 890 gpm.



Pump Combinations – Large Flow Range (2 of 2)

Q: A project requires a pump head of 60 ft but Q varies (250-1000 gpm). Will this pump work? →

A: Yes, but inefficiently for some flows (250 gpm)



Using Pumps in Parallel

Concepts and Visualization

Pumps in Parallel: Flows are additive for a given pump head.

Q: A project requires a pump head of 60 ft, but Q varies (250 to 1000 gp m). Design an efficient pump system.

A: Use two pumps in parallel: Pump 1 → high efficiency for Q=250 to 500 gpm & Pump 2 → high "e" for Q=300 to 550 gpm. Use both pumps for high flows.

Figure 5.11 Pumb Characteristics for two pumps in paralel

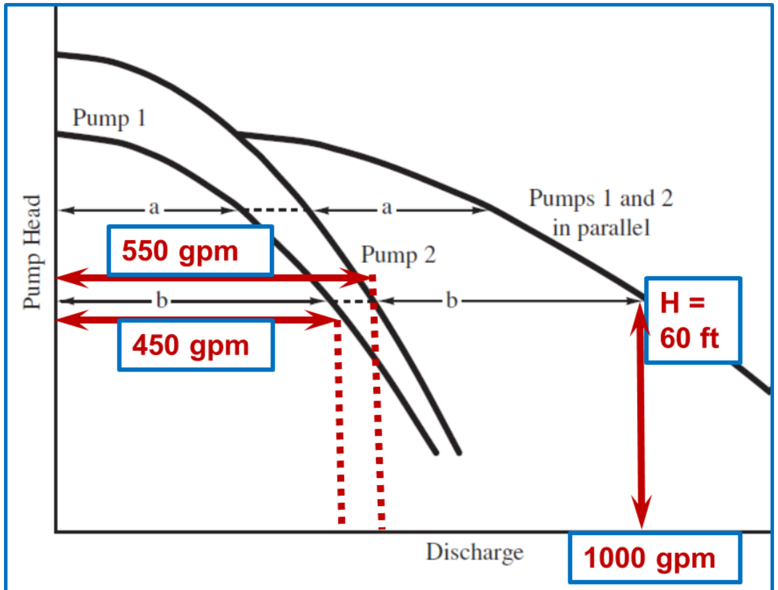


Figure 5.11 Pump characteristics for two pumps in parallel

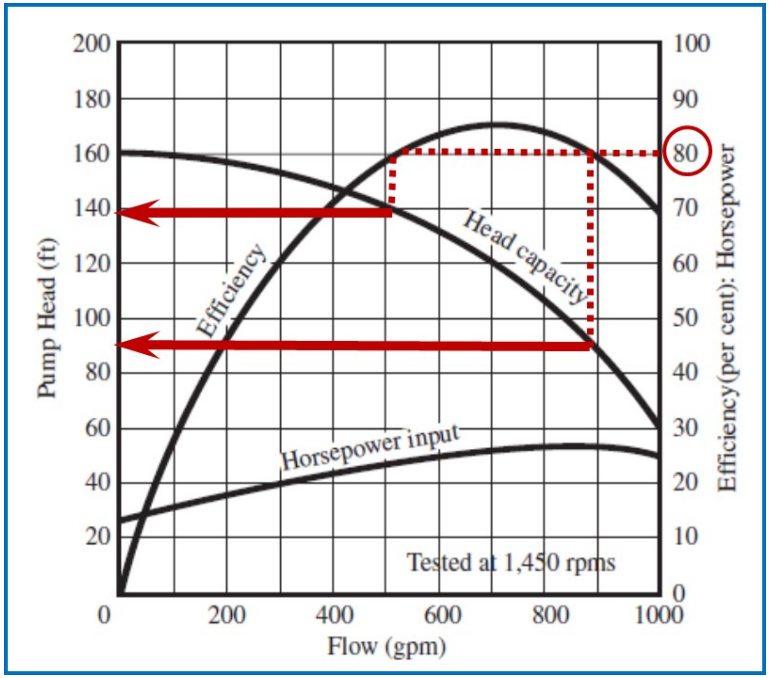
Pump Combinations – Large Head Range (1 of 2)

Concepts and Visualization

Design Objective: Operate pumps at their peak efficiency.

Q: What is the pump head range for operating this pump at efficiencies greater than 80%.

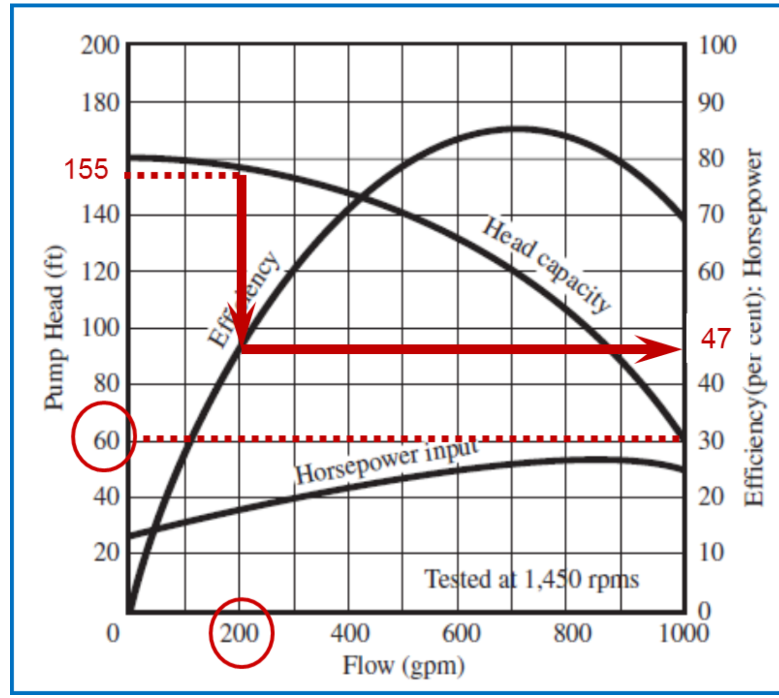
A: From 90 to 140 feet.



Pump Combinations – Large Head Range (2 of 2)

Q: A project requires a flow of 200 gpm, but H_p varies (60 to 155 feet). Will this pump work? →

Ans. Yes, but inefficiently for some heads (155 ft)



Using Pumps in Series

Concepts and Visualization

Pumps in Series: Heads are additive for a given pump flow.

Q: A project requires a flow of 200 g pm, but H_p varies (60 to 155 feet). Design an efficient pump system.

A: Use two pumps in series: Pump 1 → high efficiency for $H_p = 40$ to 80 ft & Pump 2 → high "e" for $H_p = 45$ to 90 ft. Use both pumps for high heads.

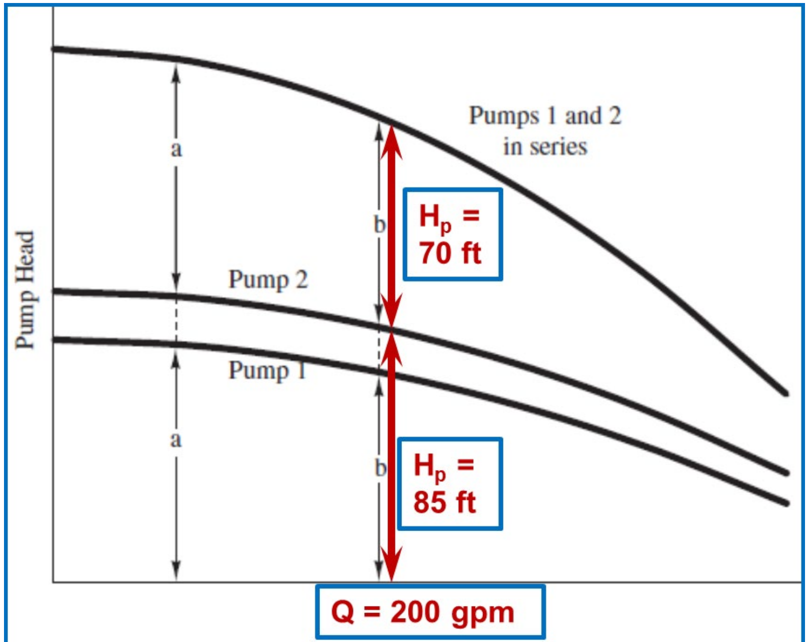


Figure 5.12 Pump characteristics for two pumps in series

Analysis of Pumps in Series and Parallel

Example Problem 5.4 (use pump of Fig. 5.13 characteristics)

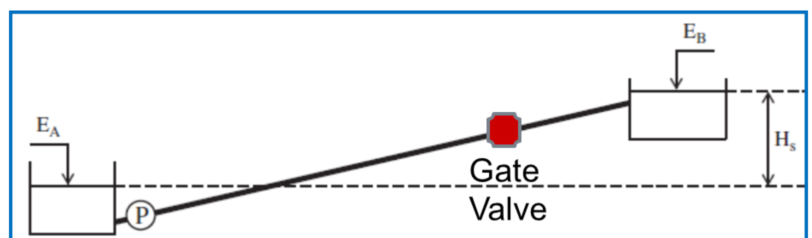
For a pump-pipeline system; $E_B = 90\text{m}$, $E_A = 80\text{m}$, $L = 300\text{m}$,
$D = 40\text{cm}$, $e = 0.12\text{mm}$, $\nu = 1.31 \times 10^{-6}\text{m}^2/\text{sec}$. Find the Q, e, and H_p for 1 pump, 2 pumps in series, & 2 pumps in parallel.

Solution: From an energy balance: $E_A + H_p = E_B + h_L$

$$or\ H_p = H_S + \frac{\left(\left(\frac{fL}{D}\right) + \sum K\right)V^2}{2g};\ \text{where } H_s = E_B - E_A = 10\text{ m}$$

Note: The pump adds energy to overcome static lift (H_s), friction loss, and minor losses. Note that $\sum K = 1.65$

Determine the system head curve for this pipeline.

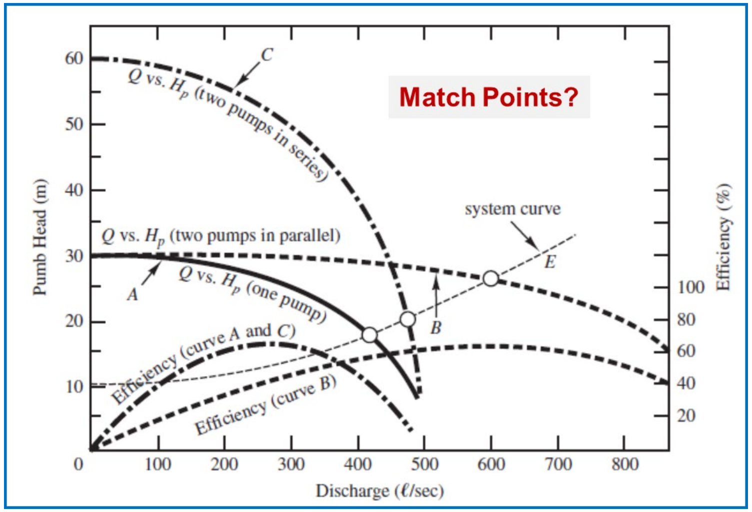


Pumps in Series and Parallel

Fill in the solution table →

Q(L/sec)	V(m/sec)	N_R	f	H_{SH}(m)
0	0	–	–	10.0
100	0.80	2.44×10^5	0.0175	10.5
300	2.39	7.30×10^5	0.0160	14.0
500	3.98	1.22×10^6	0.0155	20.7
700	5.57	1.70×10^6	0.0155	31.0

Plot **the** system head curve on the pump's characteristic curves. Find the Q, e, and H_p for 1 pump, 2 pumps in series, & 2 in parallel.



Cavitation in Water Pumps

Visualization and Energy Conservation Principles

(See Example 5.8)

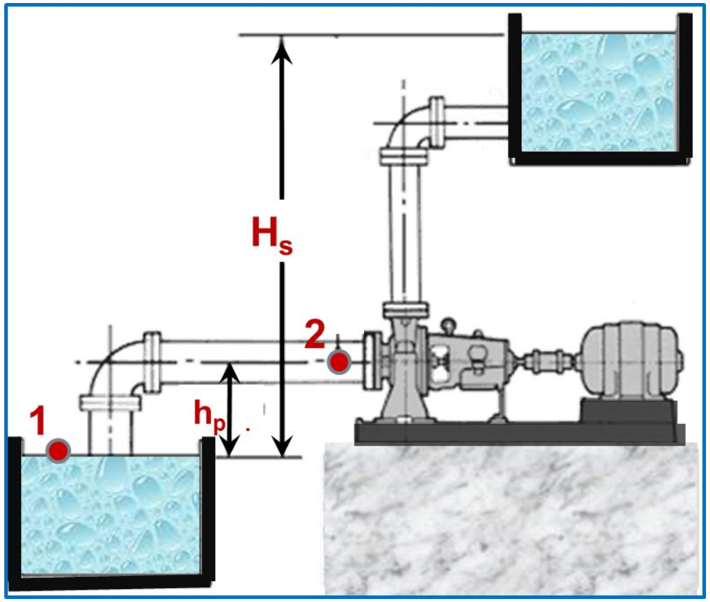
Q: Balance energy between points 1 and 2 (figure below).

$$\mathbf{A:}\ h_1 = h_2 + \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + h_L \quad \text{where } h_2 - h_1 = h_p = \text{ht. of pump}$$

Q: Solve for $\frac{P_2}{\gamma}$:

$$\mathbf{A:}\ \frac{P_2}{\gamma} = -h_p - \frac{V_2^2}{2g} - h_L$$

High negative pressure may cause water to vaporize & cavitation is to be avoided.



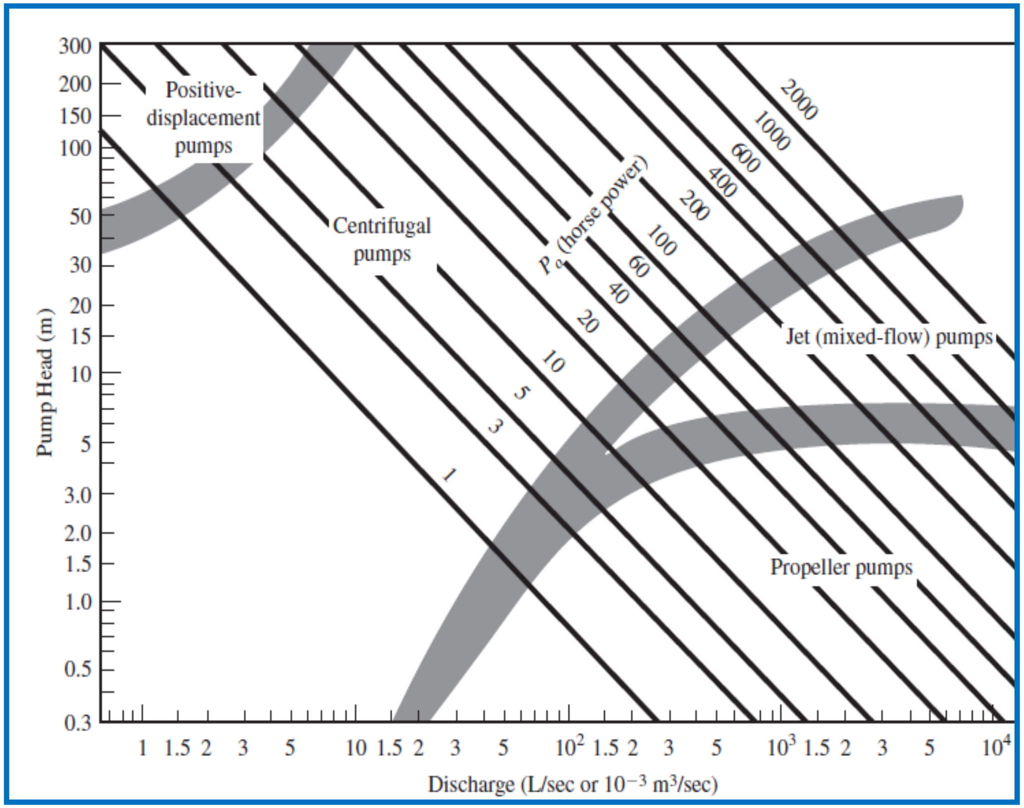
Q: How does a designer avoid cavitation problems?

A: Pump placement (h_p)

Selection of a Pump (1 of 3)

Visualization and Design Concepts

Q: What is the best type of pump for high heads and low flows? …for low heads and high flows? What is the best type for a broad range of flow and head conditions?



Selection of a Pump (2 of 3)

Design Concepts and Example Problem 5.11

The required flow for a pipeline is 70 L/sec. Based on the energy equation, the required pump head is 40 m. Based on the manufacture's pump selection chart, either Pump I or Pump II will work. The characteristic curves for each pump are shown on the next slide.

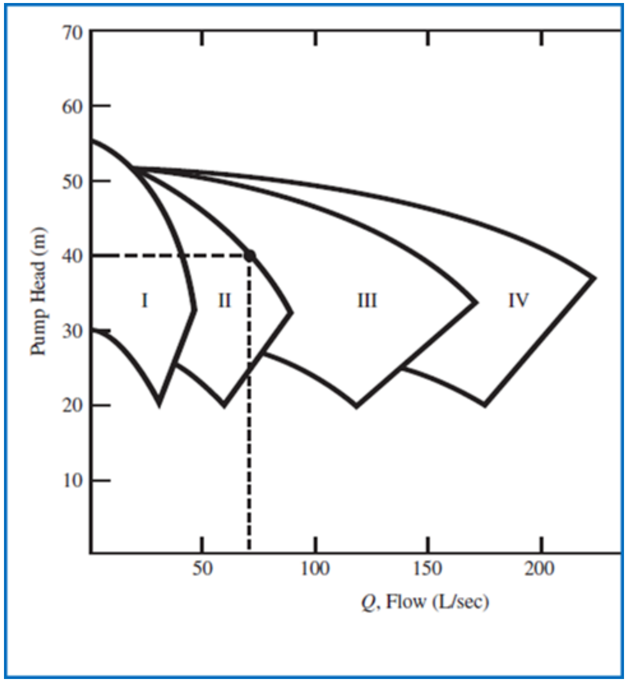
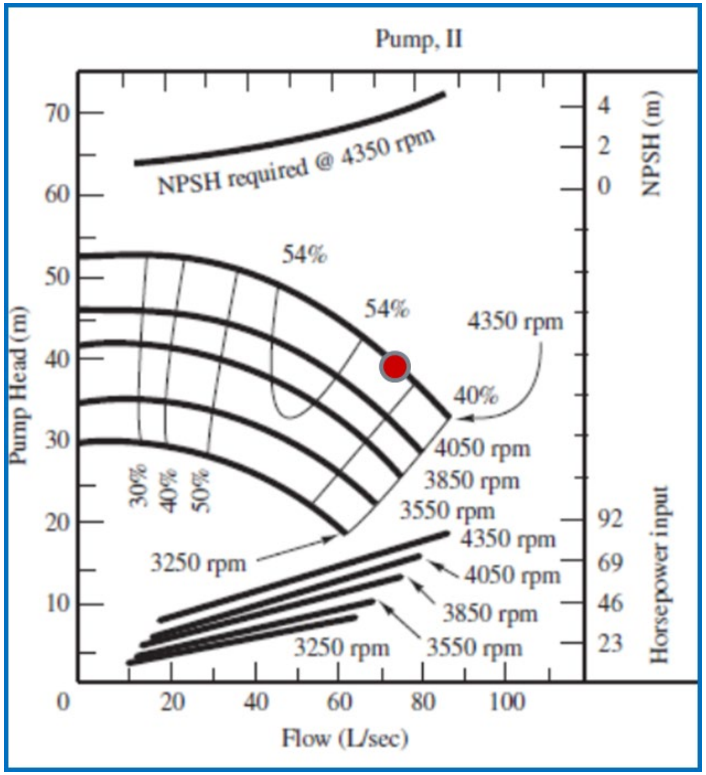
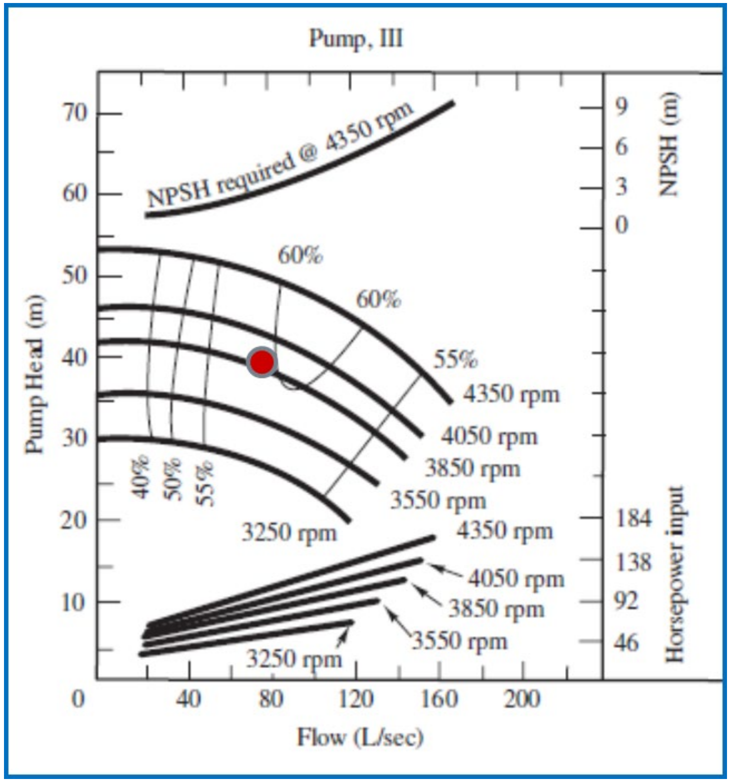


Figure 5.23 Pump Model Selection chart

Selection of a Pump (3 of 3)

Q: Choose the best pump and state its operating conditions.





Water Pumps in Parallel

City of Lakeland, Florida

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