Florida International University, Department of Civil and Environmental Engineering

CWR 3201 Fluid Mechanics, Fall 2018

Hydraulic Pumps

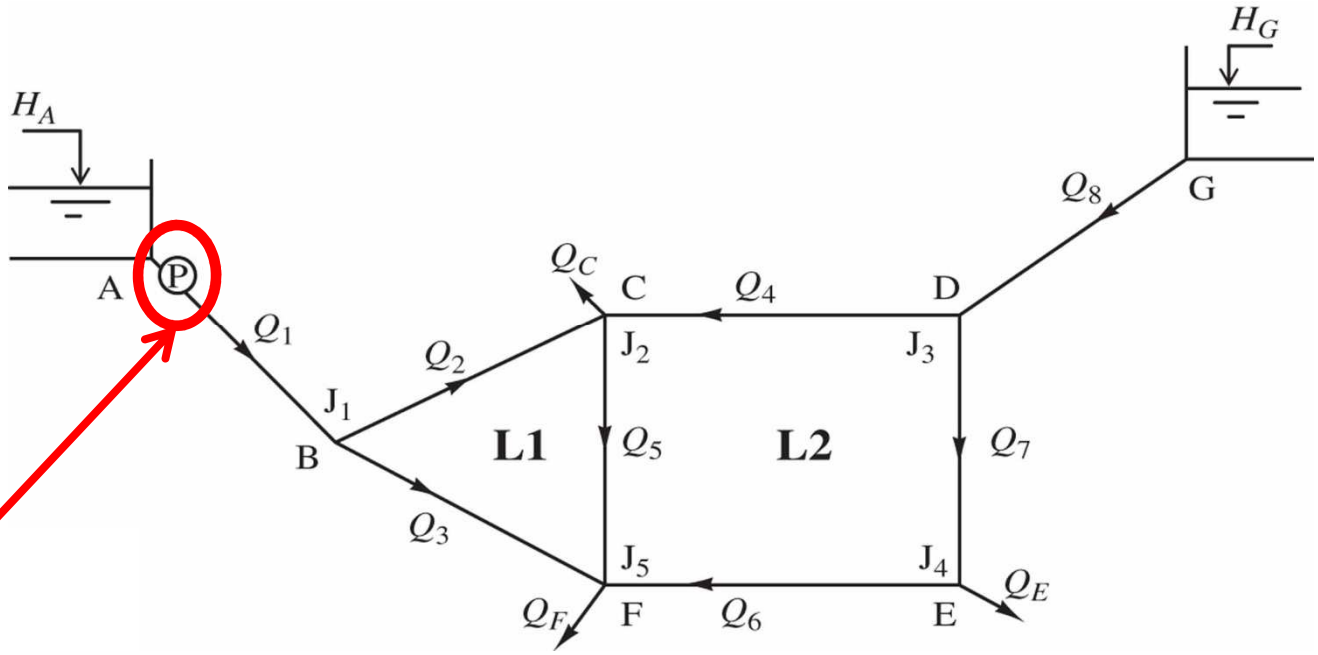
Arturo S. Leon, Ph.D., P.E., D.WRE

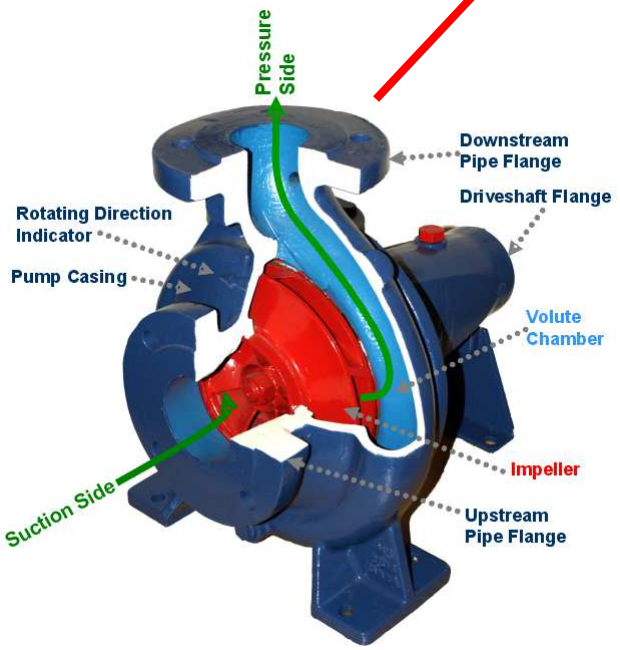
Hydraulic Pump Videos:

Centrifugal pump [Most used pump]
https://www.youtube.com/watch?v=BaEHVpKc-1Q

RAM pump [No external energy is required]
https://www.youtube.com/watch?v=aUTjVovpKvA

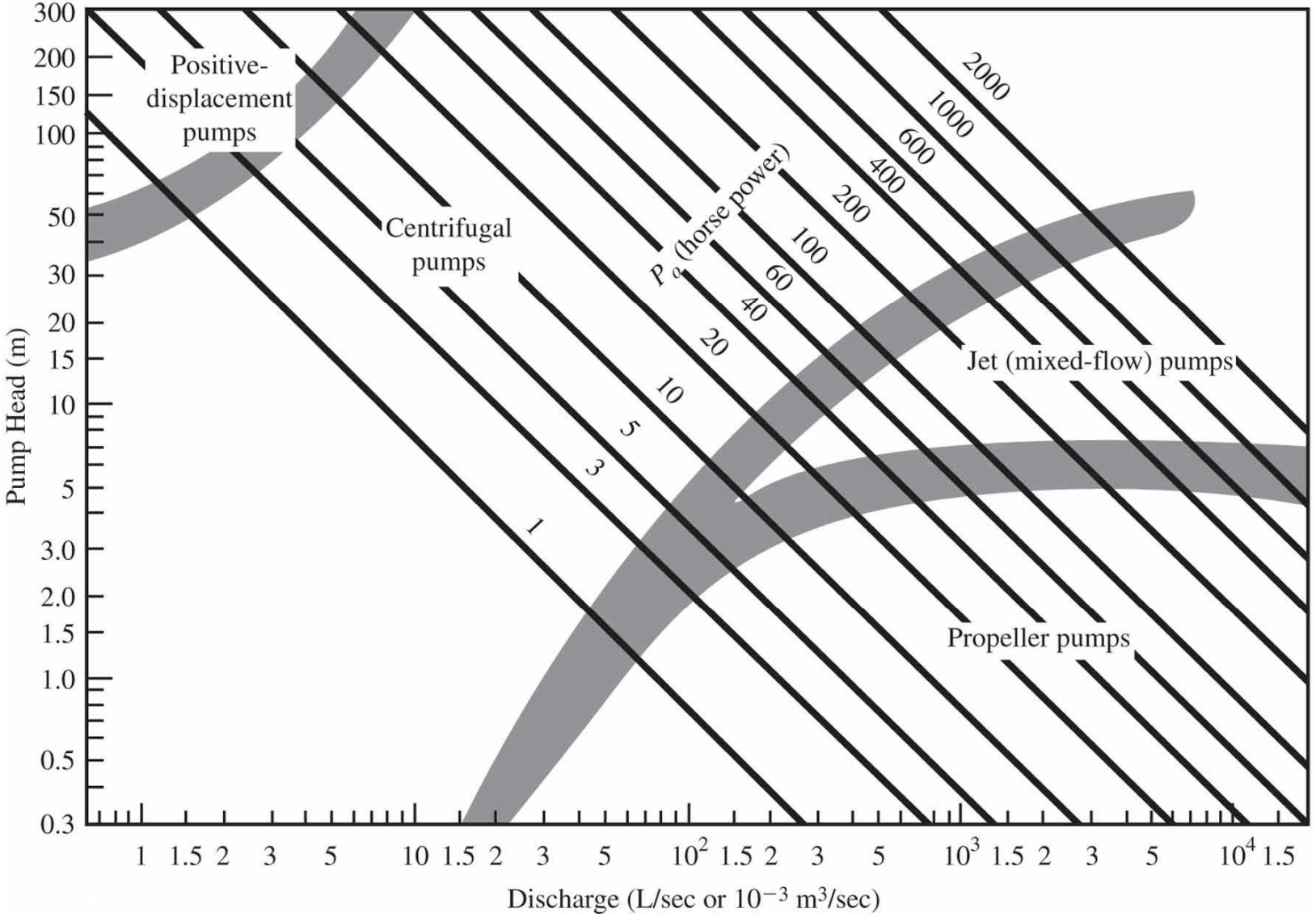
Pipe Network with Hydraulic pumps



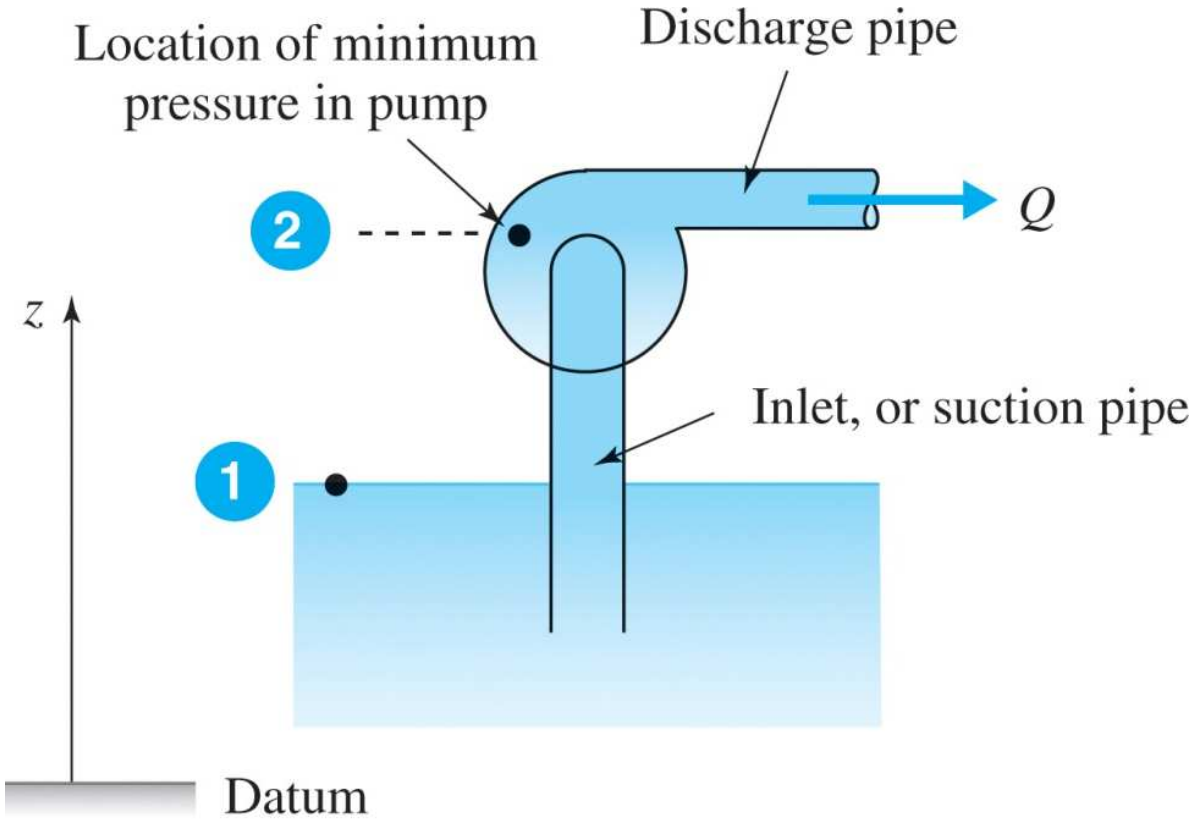


A hydraulic pump adds energy to a system, with the result that the pressure is increased.

Typical discharge, head, and power requirements for different types of pumps



Pump Performance Characteristics



H_p = actual head gained by the fluid from the pump

Pump Performance Characteristics (Cont.)

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Where: γ in lb/ft^3, Q in ft^3/s and H_p in ft

$\boldsymbol{\eta}$ = overall efficiency

Pump Performance Characteristics (Cont.)

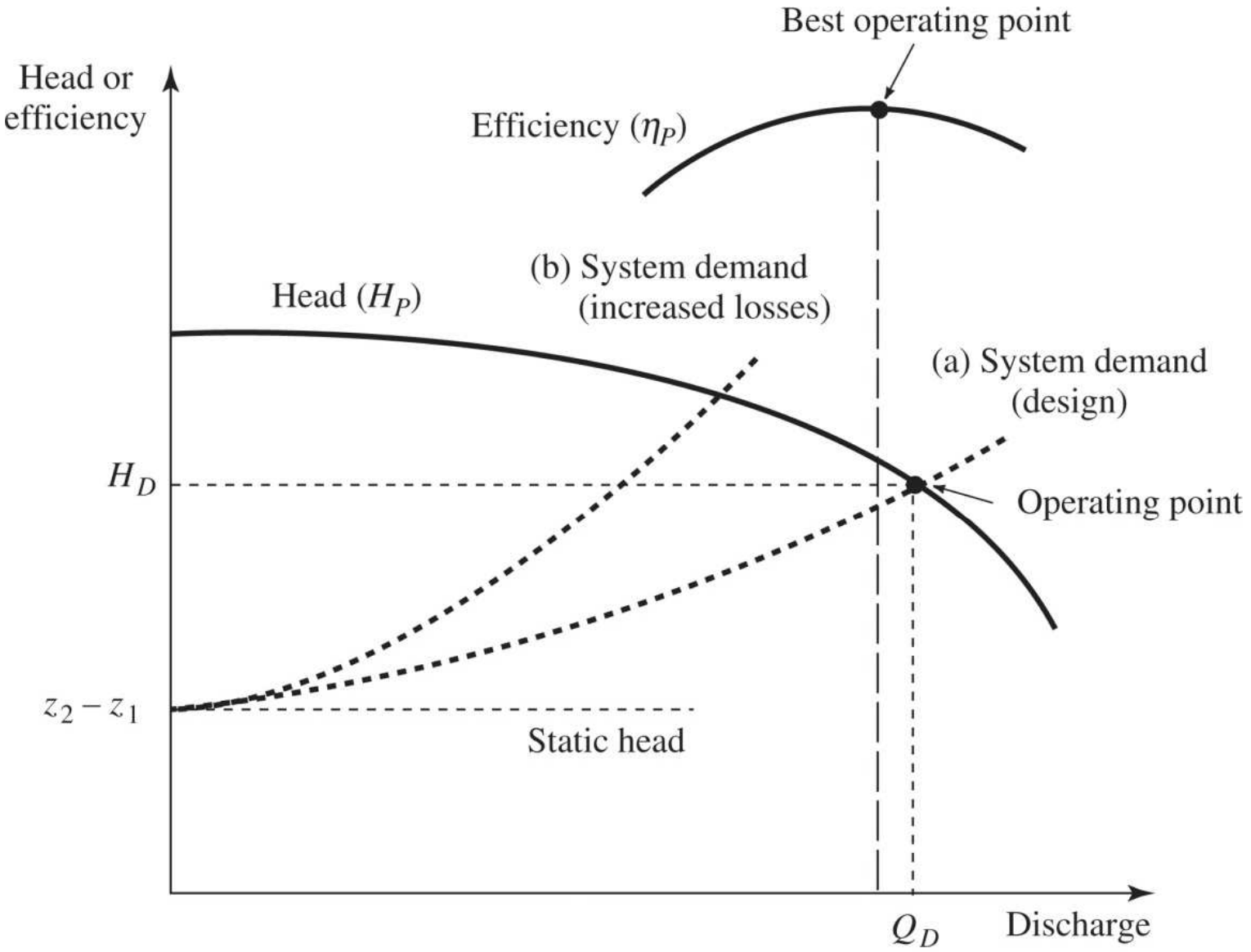
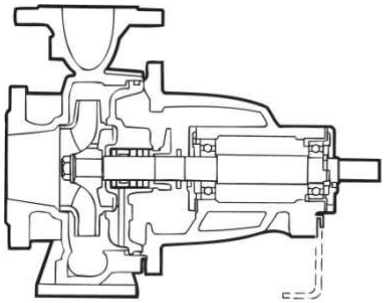


Fig. 12.16 Pump characteristic curve and system demand curve.



Pump Performance Characteristics (Cont.)

Performance curves for four different impellers for a radial-flow pump (2900 RPM)

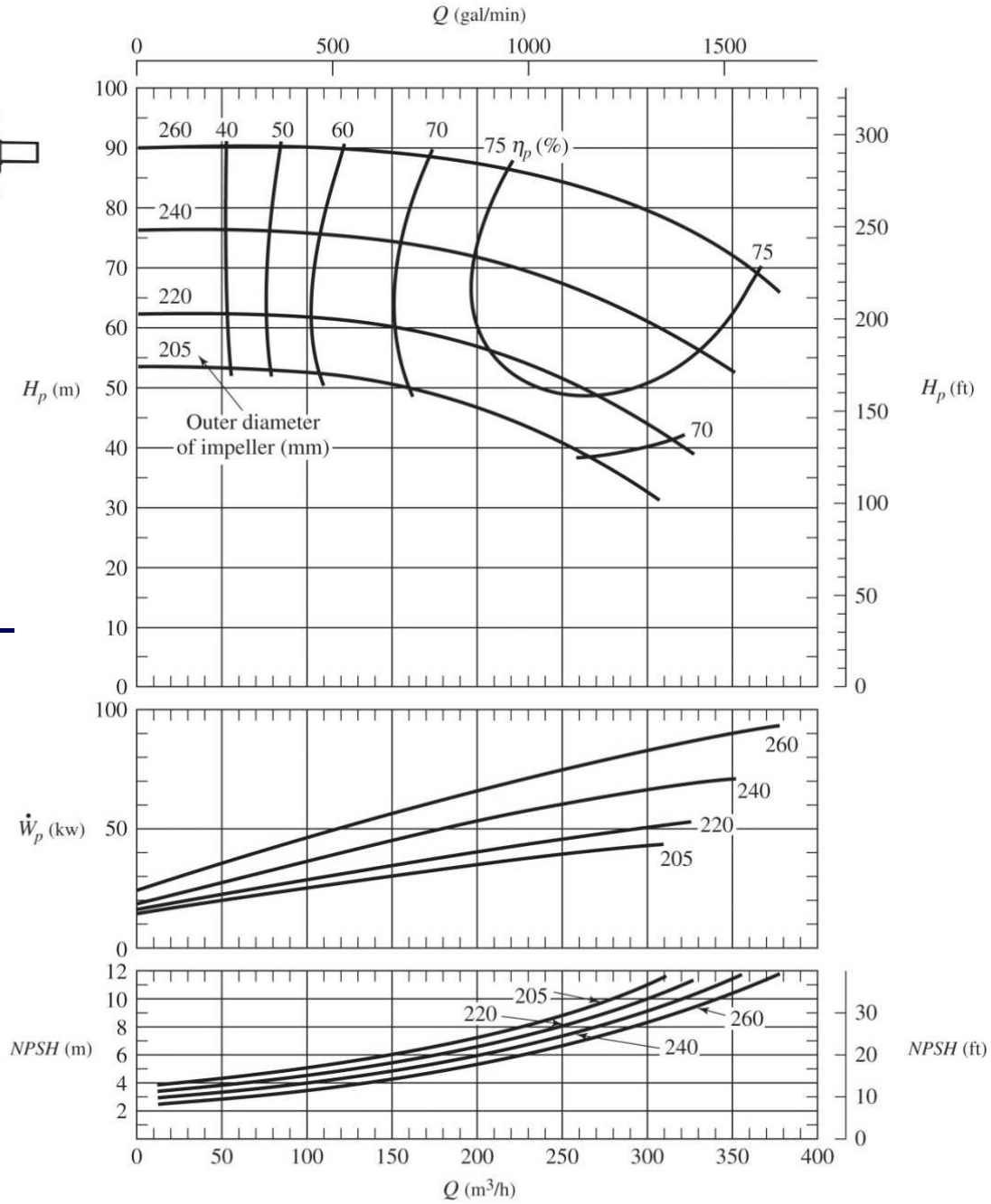


Fig. 12.6 Radial-flow pump and performance curves for four different impellers with $N = 2900$ rpm ($\omega = 304$ rad/s). Water at 20°C is the pumped liquid. (Courtesy of Sulzer Pumps Ltd.)

Net Positive Suction Head

Net Positive Suction Head (NPSH)

- On the suction side of a pump, low pressures are very common. Check for cavitation (Vapor pressure).
- Cavitation occurs when the liquid pressure at a given location is reduced to the vapor pressure of the liquid.
- How to characterize the potential for cavitation…

NPSH

Energy Equation between 1 and 2 (using absolute pressure)

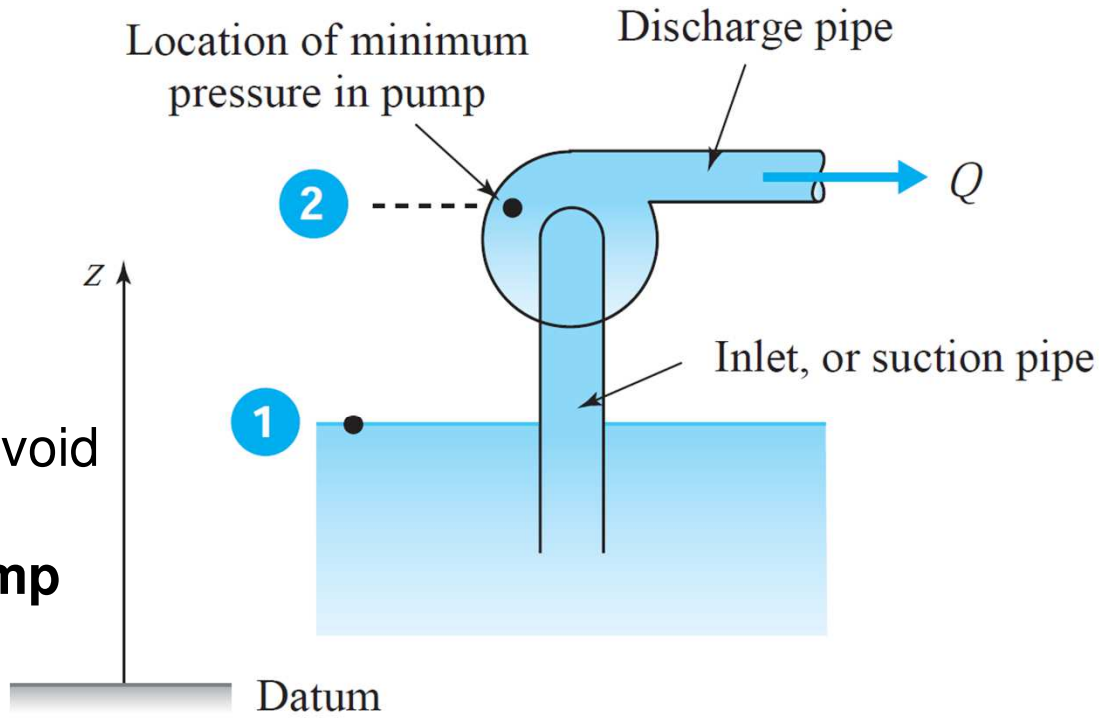


Fig. 12.11 Cavitation setting for a pump.

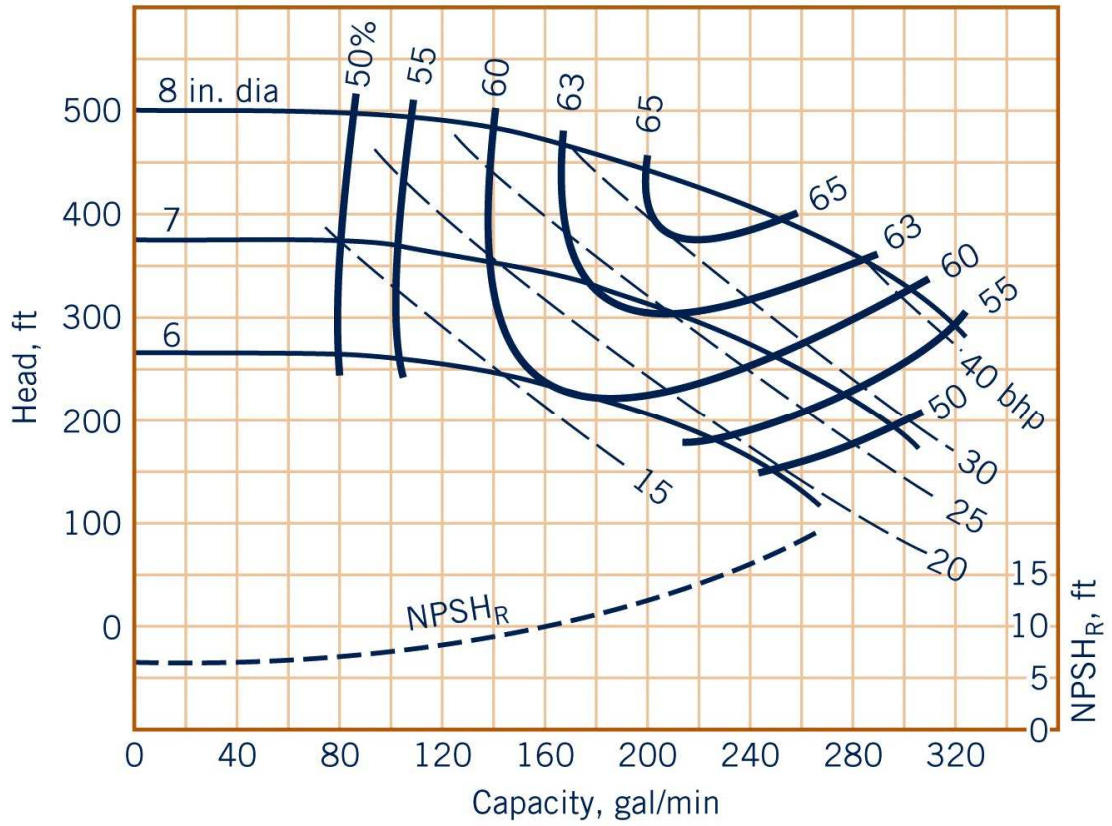
$NPSH_A$ = **Theoretical NPSH** to avoid cavitation

$NPSH_R$ = **NPSH provided by pump manufacturer**

p_v = vapour pressure

Example of application (P12.21):

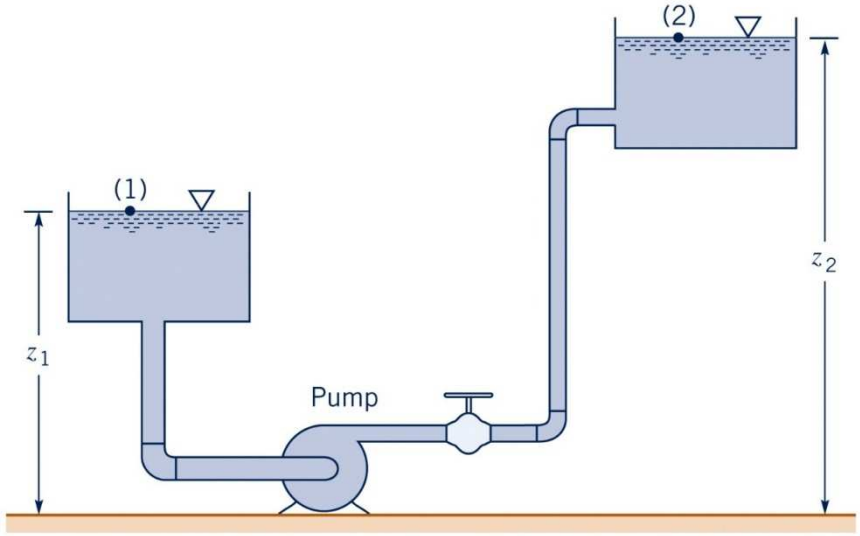
A centrifugal pump with a 7-in diameter impeller has the performance characteristics shown below. The pump is used to pump water at 100^{o} F, and the pump inlet is located 12ft above the open water surface. When the flow rate is 200 gpm, the head loss between the water surface and the pump inlet is 6 ft of water. Would you expect cavitation in the pump to be a problem? Assume standard atmospheric pressure.

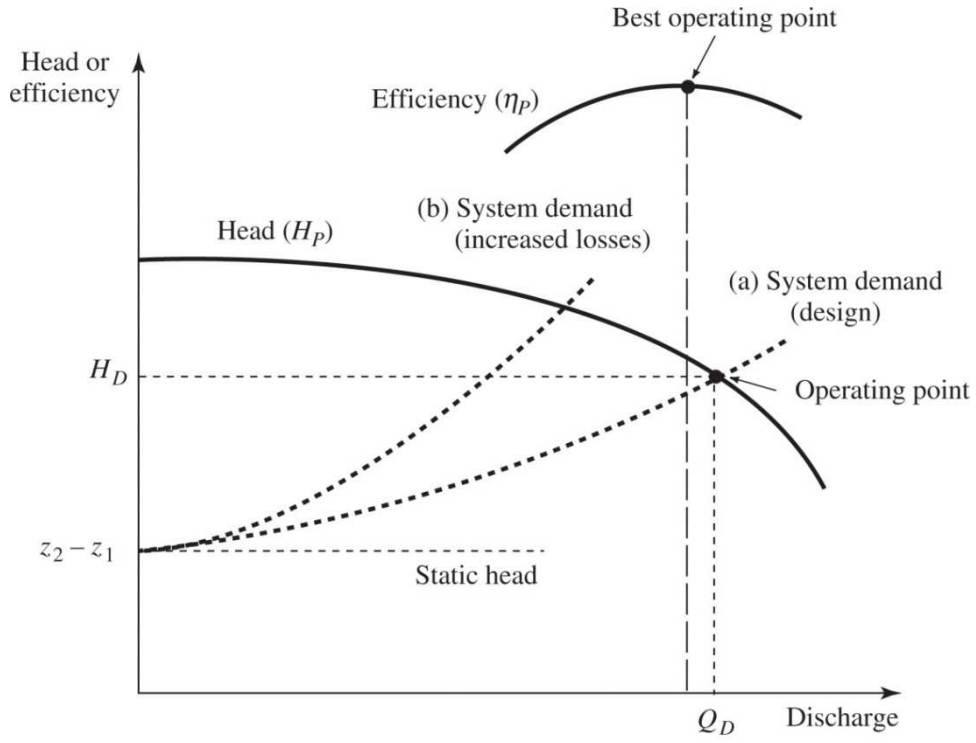


System Characteristics and Pump Selection

System Characteristics and Pump Selection

The energy equation between points (1) and (2) gives





System demand curve:

H_p = actual head gained by the fluid from the pump

System Characteristics and Pump Selection

- To select a pump, it is necessary to utilize both the **system curve** (**determined by the system equation**), and the **pump performance curve**.
- The intersection of both curves represents the **operating point for the system**.
- The operating point should be near the best efficiency point.

Pumps in Parallel

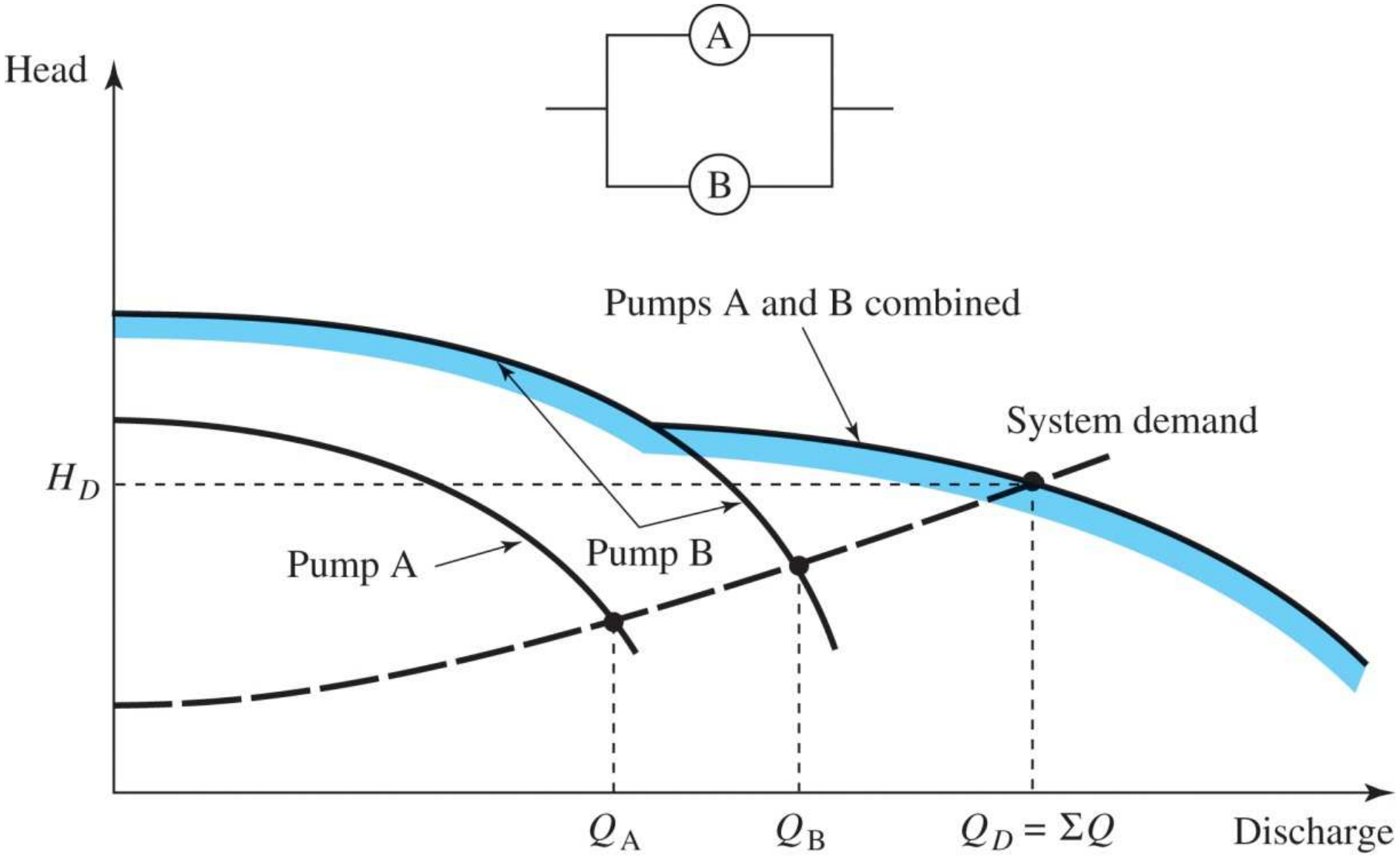


Fig. 12.17 Characteristic curves for pumps operating in parallel.

Pumps in Series

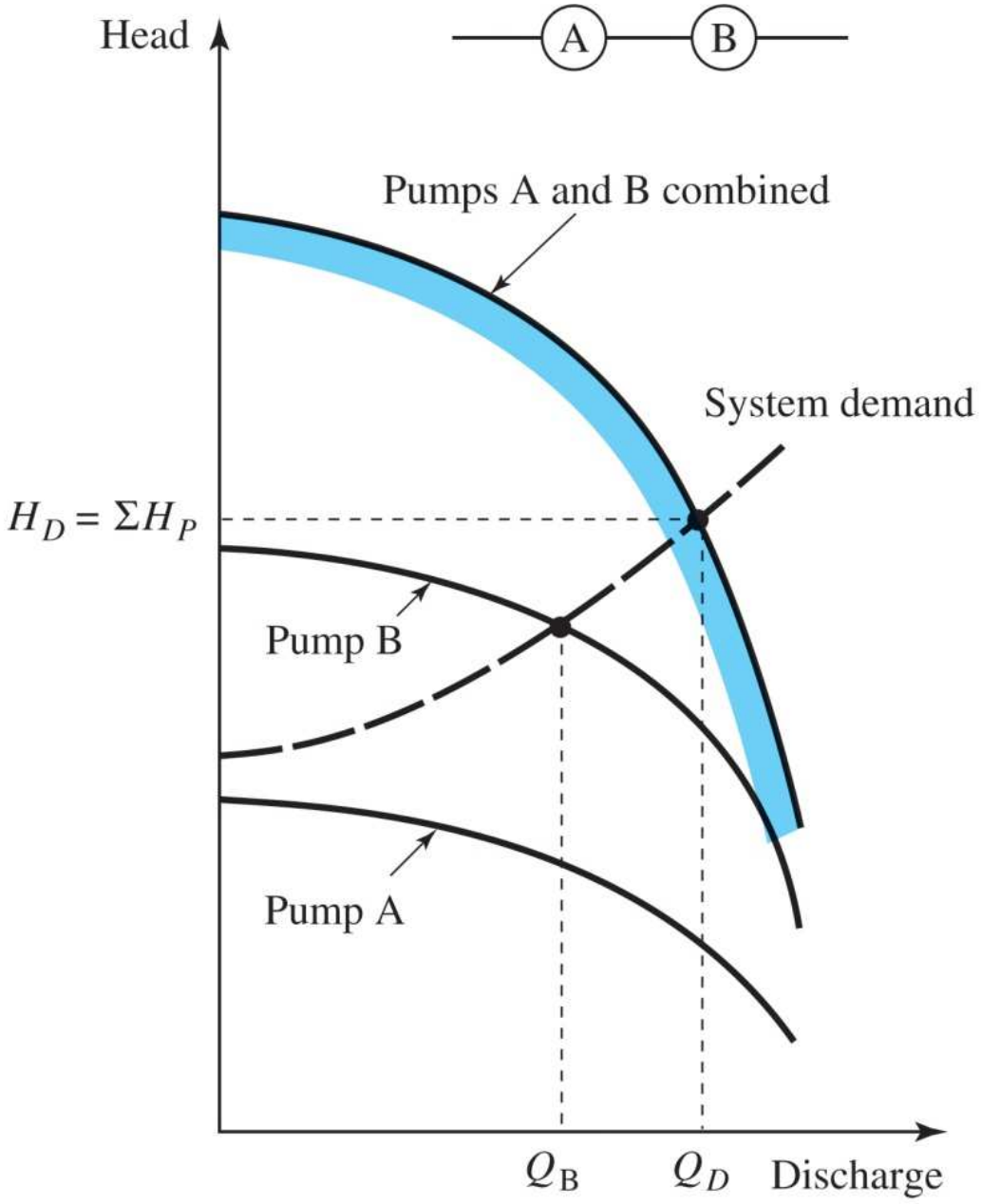
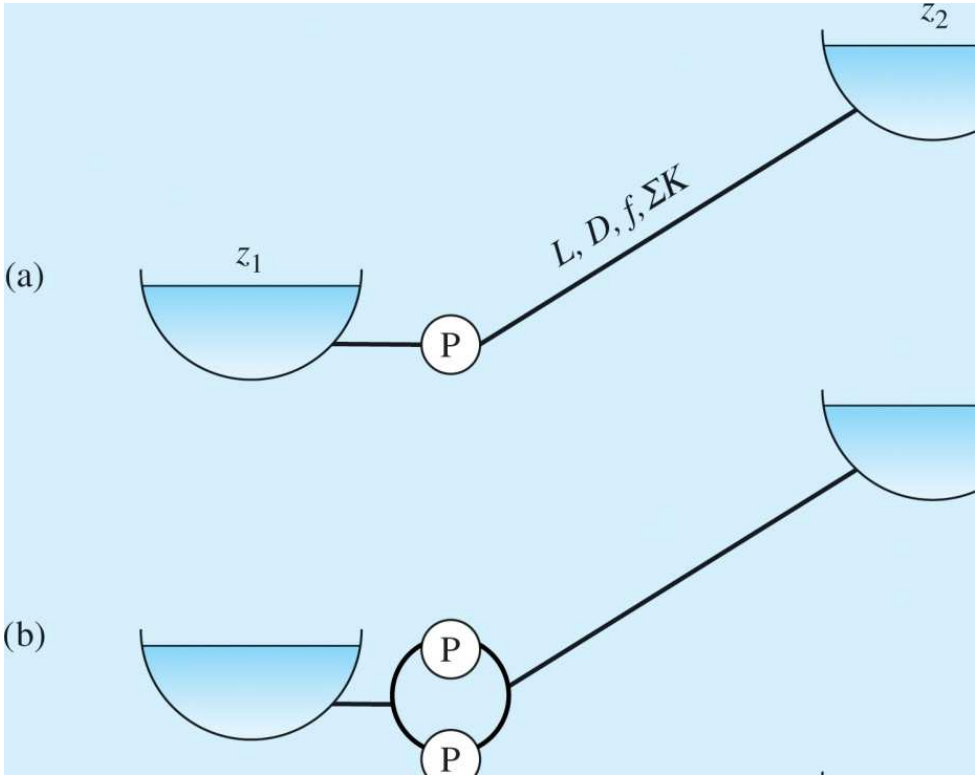


Fig. 12.18 Characteristic curves for pumps operating in series.

Example 12.7. Water is pumped between two reservoirs in a pipeline with the following characteristics:
$D = 300$ mm, $L = 70$ m, $f = 0.025$, $\Sigma K = 2.5$. The radial-flow pump characteristic curve is approximated by the formula

$$H_P = 22.9 + 10.7Q - 111Q^2$$

where H_P is in meters and Q is in m^3/s. Determine the discharge Q_D and pump head H_D for the following situations:
(a) $z_2 - z_1 = 15$ m, one pump placed in operation; (b) $z_2 - z_1 = 15$ m, with two identical pumps operating in parallel; and (c) the pump layout, discharge, and head for $z_2 - z_1 = 25$ m.



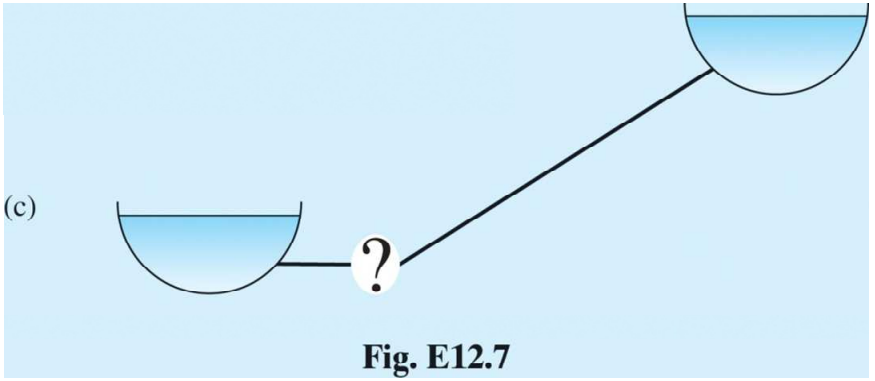


Fig. E12.7