Pumps

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Pump Selection

- Pump Type
  - Common types are horizontal volute (centrifugal) and vertical diffuser (turbine)

Pump Selection

- Pump Type
  - Horizontal Volute **"CENTRIFUGAL"**
    - less expensive
    - needs priming
  - Vertical Diffuser **"TURBINE"**
    - more expensive
    - can be positioned below the water surface
    - used in deep wells or with surface sources where it is not practical to position horizontal volute pumps
    - eliminates the need for priming

Pumps

- Reciprocating (piston or diaphragm displacement)
  - high pressure, low capacity
  - susceptible to sediment
- Rotary (gears, vanes, lobes, and screws)
- Centrifugal or impeller pumps - (uses centrifugal force imparted to fluid by one or more rotating impellers)

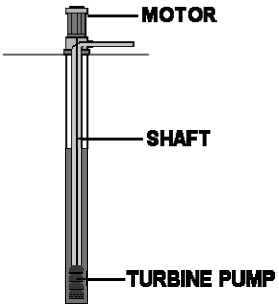
Pumps

- Impeller Pumps
  - Centrifugal
    - Radial flow pump = fluid moves through the pump perpendicular to the axis of rotation
  - Propeller
    - Axial flow pump= fluid moves through the pump parallel to the axis of rotation of the propeller
  - Turbine Pump
    - Mixed flow pump = fluid moves at some angle between radial and axial from the impeller

Centrifugal pump

Propeller pump

Turbine pump (vertical turbine)



Pump Performance

- Performance Parameters
  - Pump Capacity
    - volume of water per unit time delivered by the pump
  - Head
    - net work done on a unit weight of water by the pump
      - sum of the pressure head and elevation head at any point in a pipeline plus the friction head loss due to flow friction between two points

Pump Performance

- Performance Parameters (cont)
  - Power
    - Water Power
      - power imparted to the water by the pump

$$WP = \frac{QH}{K}$$

Where: WP = water power (hp, kW)
Q = pump capacity (gpm, l/min)
H = head (ft, m)
K = unit constant = 3960, 6116

Pump Performance

- Performance Parameters
  - Power (cont)
    - Brake Power (purchased horsepower)
      - accounts for pump efficiency
      - power input into the pump shaft

$$BP = \frac{WP}{E_P}$$

- Where: WP = water power (hp, kW)
E_P = pump efficiency
BP = brake power (hp, kW)

Dynamic head

- An operating water supply system has water flowing through the pipes. The head under which the system is operating is dynamic.
- The dynamic head is made up of several heads, defined as follows.

Dynamic head (cont.)

- Operating (Pressure) Head (H_o)
  - head required to operate the system correctly
  - usually provided in manufacturer's literature in terms of pressure which must be converted to units of head
- Elevation Head (Z)
  - head required to lift water from one level to another level (pipe pressure decreases uphill)
  - elevation head can be negative if pipe flows down hill (pipe pressure will increase)

Pump Terminology

- Friction Head (H_F) – calculated with velocity head
  - Pipe Friction Losses (H_L)
  - Minor Losses through fittings (M_L)

Velocity Head (VH)

- since water is flowing in pipe this represents energy, work must be done by the pump to attain this condition

$$VH = \frac{V^2}{2G}$$

G=acceleration due to gravity 32.2ft/sec^2 (9.81 m/s^2)

Pump Terminology

- Velocity Head

$$VH = \frac{V^2}{2G}$$

- How do I determine V (velocity)?

$$Q = VA$$

Pump Terminology

- Dynamic Head
  - Total Dynamic Head (System Head, H_s)

H_s = total elevation head + pressure head + friction head + velocity head, or:

$H_s = SL + DL + DD + H_L + M_L + H_o + VH$

Where: H_s = system head (ft,m)
SL = suction side lift (ft,m)
DL = discharge side lift (ft,m)
DD = water source drawdown (ft,m)
H_L = pipe friction head loss (ft,m)
M_L = minor losses through fittings (ft,m)
H_o= operating head (ft,m)
VH = velocity head (ft,m)

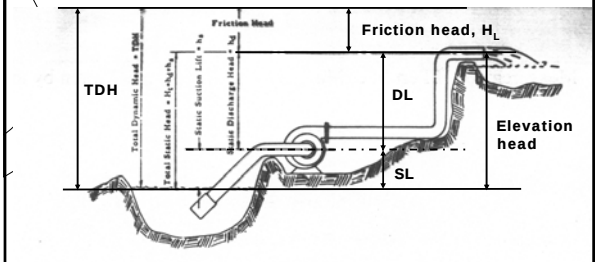


FIGURE IX-2
Suction lift conditions where the surface of the water source is below the center line of the pump.

Note: Total static head = static suction lift + static discharge head (DL)

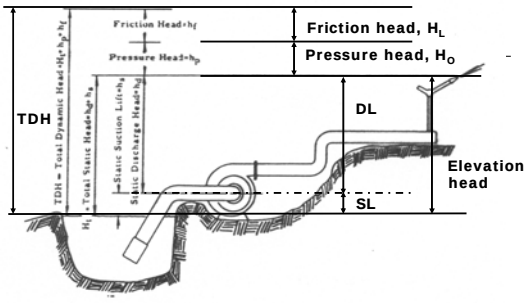


FIGURE IX-3
Same as above with sprinkler added to the system.

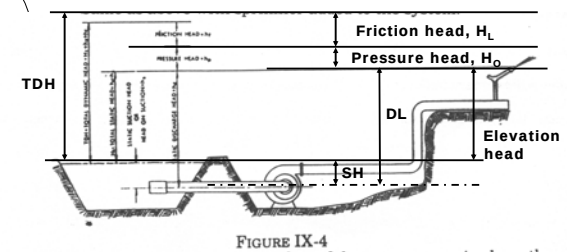


FIGURE IX-4
Suction lift conditions where the surface of the water source is above the center line of the pump.

Note: Total static head = static discharge head (DL) - static suction head

Performance (Characteristic) Curves

- Head Vs. Pump Capacity Curves
  relates the head produced by a pump to the volume per unit time of water being pumped
  - Shutoff Head
    - maximum head which the pump will develop
    - occurs when the pump is operating against a closed valve
    - pump efficiency is equal to zero at shutoff head

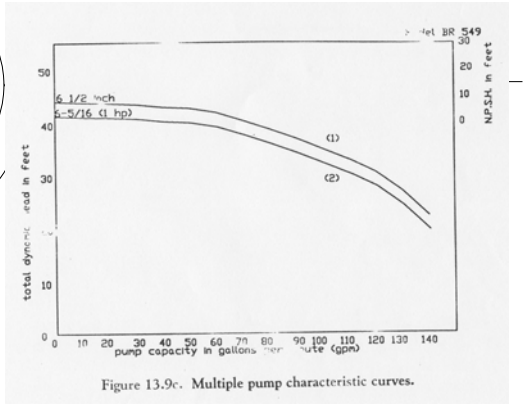


Figure 13.9c. Multiple pump characteristic curves.

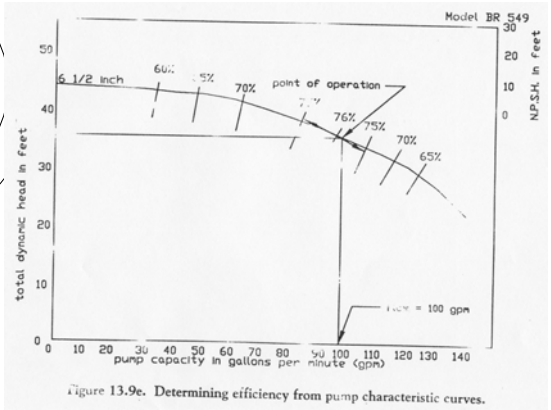


Figure 13.9e. Determining efficiency from pump characteristic curves.

Performance Curves for Pump Combinations

- Pumps in Series
  - used to increase the system head

Performance Curves for Pump Combinations

- Pumps in Parallel
  - obtain water from a common source and discharge into a single outlet
  - used to increase discharge

Performance Curves for Pump Combinations

- Pump Operating Point
  - point where the pump curve and pipe system curve intersects
  - System Curves:

$$H_S = SL + DL + DD + H_L + M_L + H_o + VH$$

Pump Selection

- Involves specifying the performance requirements of the system, selecting the required pump types, and identifying alternate pumps

Pump Performance

- Performance Parameters
  - Required Net Positive Suction Head ($NPSH_r$)
    - head required to move water into the pump
    - head required to prevent cavitation
    - cavitation:
      - formation and collapse of vapor filled cavities within pump
      - sounds like rocks in a hub cap or popcorn popping

Pump Selection

- Available Net Position Suction Head ($NPSH_a$)
  - used to determine if a pump's $NPSH_r$ can be met
  - need $NPSH_a \geq NPSH_r$

Pump Selection

- Available Net Position Suction Head ($NPSH_a$)

$$NPSH_a = P_B - VP_W - (H_L)_S - (M_L)_S - VH_S - SL - DD$$

Where:

P_B = barometric pressure (m of water)
VP_W = vapor pressure of water (m of water)
$(H_L)_S$ = friction loss in the suction loss (m)
$(M_L)_S$ = suction line minor losses (m)
VH_s = suction line velocity head (m)
SL = suction side lift (m)
DD = drawdown