Sizing and Specifying Domestic Water Boosters

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Dedication

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Our Goal

✓ Did your design meet the technical needs?
✓ Was the product the best value for the budget?
✓ If something broke, did the pump system still run?
✓ Can you buy replacement parts 20 years later?
✓ Does it still run automatically years after shipment?
Domestic Water Boosters

✓ What’s New
✓ What’s Wrong
VFD Benefits

• ENERGY SAVINGS
• Smooth hydraulics
• System pressure adjustment
• Maintenance of PRV’s
Dust
Energy Savings

- Tank
- Tank Location
- Pump Duty Point
- Pump Speed
- Pump Type
- VFD
New Tank Tricks
Low Flow Verification Problem

- Flow switch (1 FPS) – $
- Paddlewheel flow sensor (1/4 FPS) – $$
- Magnetic flow sensor (1/8 FPS) – $$$$$$

- 10 GPM in a 4” pipe = 1/4 FPS
- 10 GPM in a 6” pipe = .12 FPS
Solution

- Sense low flow (power, pump differential, speed)
- Slow down pump
- TEST to see if pressure holds
- Stop pump if pressure holds
Overpressurization

- Just before shutdown
- 10 psi standard
- Adjustable
New Sequencing Tricks

- Pressure
- Flow
- Current
- VFD Speed
- Power
- Differential Pressure
- Combinations thereof
Problem

• Flow sequencing is best way to prevent pump cavitation BUT . . .
  – Flow switches: inaccurate, unreliable
  – Flow sensors: unreliable, expensive
  – Installation is expensive, unreliable
Solution

- Pressure
- Power
- Differential Pressure
- VFD Speed
Power vs. Pressure

[Graphs showing relationships between capacity, efficiency, NPSH, PUMP EFF, T.D.H., and SHAFT POWER vs. capacity (USGPM) and total head (M ft).]
New Pumps to Consider
Other Added Value

- Lonworks or BACNet Communication
- 3D CAD drawings/BIM integration
Sizing Basics
Do You Need a Booster?

Building Height (ft x 0.433 -> PSI) + Friction Losses + Pressure Required at Top = Pressure Required at Base of Building
+ Friction Losses

• (10% approximately)
• Bernoulli’s Equation

• Most common error today??
Pressure Required @ Top

- Flush Valves
- Cooling Tower
- High-End Showers
Do You Need a Booster?

Building Height  (ft x .433 -> PSI)
+  Friction Losses  (10% approximately)
+  Pressure Required at Top
=  Pressure Required at Base of Building
Do You Need a Booster?

Pressure Required at Base of Building
- Pressure @ flow test location
+- Elevation change
- Water Meter loss
- Water Softener loss
= Pump System Boost
Scheduling Your Booster

Pump **System** Boost (we recommend) 
+ 5 PSI Internal Losses 
\[ \times 2.31 = \text{Pump TDH (commonly spec'd)} \]
Protect Yourself!

• System Pressure
• Minimum Suction
• Maximum Suction
• Pump TDH
Pressure Control

- Bottom Zone
- Zone PRV’s
Estimating Flow

- Codes
- Practice
## Hunters vs Actual

<table>
<thead>
<tr>
<th>Occupancy Type</th>
<th>Oversized By:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apartment, Office, School</td>
<td>30-75%?</td>
</tr>
<tr>
<td>Hotels, Motels</td>
<td>25-55%?</td>
</tr>
<tr>
<td>Hospital, Schools</td>
<td>10-40%?</td>
</tr>
<tr>
<td>Stadiums</td>
<td>Just Right!</td>
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</tbody>
</table>
## Redundancy Recommendations

<table>
<thead>
<tr>
<th>Occupancy Type</th>
<th>Redundant Pumps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apartment, Office, School, Hotel</td>
<td>0</td>
</tr>
<tr>
<td>Hospital, Stadiums</td>
<td>1</td>
</tr>
</tbody>
</table>
Sizing Piping

- 5 PSI Assumed
http://www.syncroflo.com/sys12/12-Systems.swf
Pump Options
Discussion Points

- Importance of selecting the right pump
- Typical pumps used in plumbing
- Best application for each type
- Reading a pump curve
- Matching a pump with a system curve
- Optimal solution
1. Importance of the Right Pump

- The pump is the heart of any system
- Selecting the right pump for the application
- Selecting the highest efficiency pump
- Selecting a good quality pump
- Understanding the value of down time
2. Most Popular Pumps

- Close-coupled End Suction
- Vertical Turbine
- Column-mounted Turbines
- Flex-coupled End Suction
- Vertical Multistage
- Horizontal Split Case
- Self-priming
3. Most Popular Pumps

- **End Suction Close Coupled**
- Most popular pump in the world
- Small compact design
- Small flows at low to medium head
- Lowest initial cost
- Easy to maintain
End Suction Pump Curve
3. Most Popular Pumps

- **Horizontal Split Case**
- Larger foot print than end suction pumps
- Large flows and large heads
- Highest efficiencies
- Best design pump resulting in many years of trouble free service
- Used in variety of applications including fire fighting
- Relatively easy to maintain
3. Types of Pumps

**Vertical Multi-stage**

- Low flows at high heads
- Minimal space requirements
- Difficult to maintain
VMS Pump Curve
3. Types of Pumps

Canned Turbines

- Can handle large flows at very high heads
- Minimal space requirements
- Does not require a wet well
- Very high quality
- High efficiencies
VT Pump Curve
3. Types of Pumps

Self-priming

- Mainly used for lifting waste water
- Can handle large flows at low heads
- Solids handling capability
- Driver options
4. Pump Curve
MATCHING PUMP WITH SYSTEM CURVE

HEAD

FLOW

System Curves

Pump curve
Proper Pump Selection

• Understand what the overall selection criteria are for the system/equipment
• Select the type of pump that best meets the hydraulics as well as design criteria
• Select pump size closest to best efficiency point
• Select the pump according to space availability
Proper Pump Selection

• Select pump with highest possible efficiency
• Select pump from a manufacturer that offers good after sales support
Pressure Control

• Variable Speed
• Pressure Regulating Valve
• Zone PRV’s
• None Required
Tank Sizing

• Higher in the building is better if no PRV’s
• How big a tank?
  – Acceptable leak load?
  – Minimum pump flow?
  – Additional installation cost for bigger tank?
  – Maintenance, replacement of bigger tanks?
Tank Efficiency

• Bigger the better for
  – Energy savings
  – Reducing pump cycling

• Smaller the better for
  – Cost
  – Installation
  – Maintenance
Recommendations

• 100 Gallon minimum
• 36” x 80” maximum

• Top of building if any of these
  – VFD
  – No PRV
  – >200 psi
  – Steady suction pressure
ASPE Recommendation

• Leak load
  – 0.5% for most commercial buildings
  – 4% for Hospitals

• Size for 10-30 minute off time

• Locate based on largest storage opportunity, using Boyle’s Law.
VFD or not & Sequencing Options
Affinity Laws

With impeller diameter held constant

\[
\frac{Q_1}{Q_2} = \frac{N_1}{N_2} \quad \text{Law 1a}
\]

\[
\frac{H_1}{H_2} = \left( \frac{N_1}{N_2} \right)^2 \quad \text{Law 1b}
\]

\[
\frac{\text{Bhp}_1}{\text{Bhp}_2} = \left( \frac{N_1}{N_2} \right)^2 \quad \text{Law 1c}
\]

With speed held constant

\[
\frac{Q_1}{Q_2} = \frac{D_1}{D_2} \quad \text{Law 2a}
\]

\[
\frac{H_1}{H_2} = \left( \frac{D_1}{D_2} \right)^2 \quad \text{Law 2b}
\]

\[
\frac{\text{Bhp}_1}{\text{Bhp}_2} = \left( \frac{D_1}{D_2} \right)^3 \quad \text{Law 2c}
\]

Where

\( Q_1 = \text{Capacity and } H_1 = \text{head at } N_1 \text{ rpm or with impeller dia. } D_1 \)

\( Q_2 = \text{Capacity and } H_2 = \text{head at } N_2 \text{ rpm or with impeller dia. } D_2 \)
FIG. 13. Typical performance curve of a centrifugal pump with constant impeller diameter but varying speeds.
FIG. 14. Typical performance curve of a centrifugal pump at 1750 rpm but with varying impeller diameter.
VFD Effect

Fig. 15 Chart showing effect of speed change on centrifugal pump performance.
Less energy

• The pressure boost required for variable speed systems is lower than constant speed,
• Variable frequency drives (VFD's) allow no inrush current
• Decreasing the speed of a pump shifts its efficiency curve to the left.
• A VFD drive makes a pump produce the exact amount of pressure that is required at a particular flow rate.
Additional benefits:

- Easy start-ups
- More reliable and self-sufficient operation.
- Increased motor bearing and mechanical seal life
- Dramatically reduced sound and motor heat emissions
- More information is available to the operator
  - alarm logs
  - data history
  - adjustable keypad settings
  - Remote access to data
Ideal variable speed pumping application:

• Varying or unpredictable flow rates throughout a 24 hour day.
• Low or at no flow during a large portion of a 24 hour day.
• Suction pressure that is predictably higher
• High shutoff head pumps available
• Locations where noise and/or heat reduction are important design considerations.
VFD a good choice?

- Pumping to an elevated water tank or water tower
- The suction supply comes from an adjacent ground level storage tank
- Pumps have very little extra pressure at shutoff
- The pump house is located in a remote area and is fan ventilated.
VFD a good choice?

- Pumping to the upper floors of a hotel
- Cooling tower makeup and restaurant demands at the top
- Flow rates vary from low medium during the day but remain consistently low overnight
- The suction supply comes from a water main that is known to have a very high static pressure at night
- We can use vertical multi-stage pumps that are selected to the right of center for higher efficiency at the expected flow rates. The pumps produce a lot of extra pressure at shutoff
- The pump system resides in the basement mechanical room, directly underneath the meeting rooms
Pump systems are controlled based on several methods, usually all running concurrently.
Power Consumed

• Set Point Units:
• Advantages:
• Disadvantages:
• Most useful when:
Pressure

• Set Point Units:
• Advantages:
• Disadvantages:
• Most useful when:
Maximum/Minimum VFD Speed

- Set Point Units:
- Advantages:
- Disadvantages:
- Most useful when:
Flow

• Set Point Units:
• Advantages
• Disadvantages:
• Most useful when:
Conclusion

- Find a partner that you trust to provide a design that meets your needs
- OR
- Confirm that some product can meet your WHOLE specification and drawing
Online Sizing Guide

Online Resources

- http://www.pumpsystemsmatter.org/
- http://www.pmengineer.com/Articles/Cover_Story/BNP_GUID_9-5-2006_A_10000000000000327145