Designing an Efficient Liquid Plant

Requires

- Selecting the Right Equipment Components
Design with Direction

- Develop a plan
- Work from a flow diagram
  - Simple Flow Diagram
  - Cad designed diagram
- Allow a realistic time frame
Design with Direction

- Develop a plan
- Work from a flow diagram
  - Cad designed diagram
- Allow a realistic time frame
Common Themes

- Material of construction
- Product mix
- System capacity
- Quality control
- Labor
- Available power
Storage Requirements

- Turnover
- Products
- Seasonal storage
- Secondary Containment
Tanks

- Size
- Shape
- Material
- Fittings
- Foundation
Plumbing

- **Size**
  - Suction vs. Discharge
  - 2” to 150 gpm
  - 3” to 300 gpm
  - 4” to 450 gpm
  - 6” to 800 gpm
  - Upsize long runs
- Selection Criteria
  - Flow characteristics
  - Corrosion resistance
  - Strength
  - Cost of Installation
  - Flexibility for changes
  - Weld or thread?
### Friction Losses Through Screw Pipe Fittings in Terms of Equivalent Lengths of Standard Pipe

<table>
<thead>
<tr>
<th>Nominal Pipe Size Inches</th>
<th>Actual Inside Diameter Inches</th>
<th>Factor of Resistance</th>
<th>Gate Valve</th>
<th>Long-Sweep Elbow or on Run of Standard Tee</th>
<th>Medium—Sweep Elbow or on Run of Tee Reduced in Size ( \frac{3}{4} )</th>
<th>Standard Elbow or on Run of Tee Reduced in Size ( \frac{3}{4} )</th>
<th>Close Return Bend</th>
<th>Tee Through Side Outlet</th>
<th>Globe Valve</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0.662</td>
<td>0.25</td>
<td>0.33</td>
<td>0.442</td>
<td>0.42</td>
<td>0.79</td>
<td>1.07</td>
<td>2.35</td>
<td>2.35</td>
</tr>
<tr>
<td>2( \frac{1}{2} )</td>
<td>0.824</td>
<td>0.475</td>
<td>0.627</td>
<td>0.89</td>
<td>1.27</td>
<td>1.27</td>
<td>1.71</td>
<td>2.56</td>
<td>2.56</td>
</tr>
<tr>
<td>2</td>
<td>1.049</td>
<td>0.640</td>
<td>0.844</td>
<td>1.07</td>
<td>1.72</td>
<td>2.34</td>
<td>3.61</td>
<td>4.80</td>
<td>7.22</td>
</tr>
<tr>
<td>1( \frac{1}{4} )</td>
<td>1.38</td>
<td>0.902</td>
<td>1.19</td>
<td>1.61</td>
<td>2.42</td>
<td>3.24</td>
<td>5.92</td>
<td>8.72</td>
<td>11.92</td>
</tr>
<tr>
<td>1( \frac{1}{4} )</td>
<td>1.61</td>
<td>1.09</td>
<td>1.43</td>
<td>1.83</td>
<td>2.92</td>
<td>4.36</td>
<td>5.79</td>
<td>8.72</td>
<td>11.92</td>
</tr>
<tr>
<td>2</td>
<td>2.06</td>
<td>1.49</td>
<td>1.96</td>
<td>2.50</td>
<td>3.99</td>
<td>5.36</td>
<td>7.92</td>
<td>11.92</td>
<td>11.92</td>
</tr>
<tr>
<td>3</td>
<td>2.46</td>
<td>1.86</td>
<td>2.46</td>
<td>3.13</td>
<td>5.00</td>
<td>6.72</td>
<td>7.47</td>
<td>9.93</td>
<td>14.94</td>
</tr>
<tr>
<td>4</td>
<td>3.06</td>
<td>2.46</td>
<td>3.25</td>
<td>4.11</td>
<td>6.66</td>
<td>8.87</td>
<td>9.86</td>
<td>13.11</td>
<td>19.72</td>
</tr>
<tr>
<td>6</td>
<td>4.026</td>
<td>3.44</td>
<td>4.53</td>
<td>5.77</td>
<td>9.22</td>
<td>12.37</td>
<td>13.70</td>
<td>18.28</td>
<td>27.50</td>
</tr>
<tr>
<td>6( \frac{1}{2} )</td>
<td>4.57</td>
<td>5.047</td>
<td>6.00</td>
<td>7.68</td>
<td>12.20</td>
<td>16.47</td>
<td>18.30</td>
<td>24.33</td>
<td>36.60</td>
</tr>
<tr>
<td>8</td>
<td>6.065</td>
<td>5.72</td>
<td>7.55</td>
<td>9.61</td>
<td>15.30</td>
<td>20.61</td>
<td>22.90</td>
<td>30.45</td>
<td>45.00</td>
</tr>
<tr>
<td>8( \frac{1}{4} )</td>
<td>7.024</td>
<td>6.90</td>
<td>9.10</td>
<td>11.60</td>
<td>18.50</td>
<td>24.84</td>
<td>27.60</td>
<td>36.70</td>
<td>55.20</td>
</tr>
<tr>
<td>8( \frac{1}{2} )</td>
<td>7.981</td>
<td>8.10</td>
<td>10.70</td>
<td>13.60</td>
<td>21.71</td>
<td>29.16</td>
<td>32.40</td>
<td>43.09</td>
<td>64.80</td>
</tr>
<tr>
<td>10</td>
<td>10.020</td>
<td>10.70</td>
<td>14.10</td>
<td>17.97</td>
<td>28.70</td>
<td>33.62</td>
<td>42.80</td>
<td>56.92</td>
<td>85.60</td>
</tr>
<tr>
<td>12</td>
<td>12.090</td>
<td>12.50</td>
<td>17.80</td>
<td>22.68</td>
<td>36.28</td>
<td>48.60</td>
<td>54.00</td>
<td>71.82</td>
<td>108.00</td>
</tr>
</tbody>
</table>
Doubling the diameter of a pipe increases its capacity four times.
Plumbing Materials

- Hose
- PVC
- Mild steel
- Stainless steel
- Poly
- Combinations
# Cost Comparison Plumbing Materials

<table>
<thead>
<tr>
<th>Material</th>
<th>3” Pipe</th>
<th>4” Pipe</th>
<th>3” Elbow</th>
<th>4” Elbow</th>
<th>Durability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyethylene</td>
<td>$3.00</td>
<td>$5.00</td>
<td>$17.00</td>
<td>$24.00</td>
<td>Lifetime</td>
</tr>
<tr>
<td>Poly Helix EPDM Lined Hose</td>
<td>$4.00</td>
<td>$6.50</td>
<td></td>
<td></td>
<td>3-4 years</td>
</tr>
<tr>
<td>Sch80 PVC</td>
<td>$5.00</td>
<td>$7.00</td>
<td>$9.00</td>
<td>$14.00</td>
<td>4-6 years</td>
</tr>
<tr>
<td>Rubber wire Reinforcement</td>
<td>$5.00</td>
<td>$7.80</td>
<td></td>
<td></td>
<td>6-8 years</td>
</tr>
<tr>
<td>Steel Pipe</td>
<td>$11.00</td>
<td>$16.50</td>
<td>$19.00</td>
<td>$40.00</td>
<td>10-18 years</td>
</tr>
<tr>
<td>Sch10 SS Pipe</td>
<td>$16.00</td>
<td>$23.00</td>
<td>$23.00</td>
<td>$33.00</td>
<td>Lifetime</td>
</tr>
</tbody>
</table>
System using hose and prefabricated stainless steel fittings.
Pumps and Plumbing

- System Capacity
  - Load size
  - Time
  - Plan for growth
Don’t Get Stuck with the Wrong Pump!
Pump Selection

- Type
  - Self-priming centrifugal
  - Straight centrifugal
  - Positive displacement

- Capacity (not size)
- Material
- Seals & packing
Positive Displacement
Pump Performance

- Design
- Impeller
  - Size
  - Shape
- Speed
Open vs. closed impeller design pumps

<table>
<thead>
<tr>
<th>Open</th>
<th>The fluid enters the eye of the impeller where the turning vanes add energy to the fluid and direct it to the discharge nozzle. A close clearance between the vanes and the pump volute, or back plate in a few designs, prevents most of the fluid from recirculating back to the eye of the impeller. (L) shows the leading edge or higher-pressure side of the impeller. (T) describes the trailing edge of the impeller.</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Open Impeller Diagram" /></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Closed</th>
<th>The fluid enters the eye of the impeller where the vanes add energy to the fluid and direct it to the discharge nozzle. There is no impeller to volute or back plate clearance to set. Wear rings restrict the amount of discharge fluid that recirculates back to the suction side of the impeller. When this wear ring clearance becomes excessive the wear rings must be replaced.</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image2.png" alt="Closed Impeller Diagram" /></td>
<td></td>
</tr>
</tbody>
</table>
Advantages and Disadvantages

- **Closed Impeller**
  - The impeller can clog if you pump solids or "stringy material". It's difficult to clean out these solids from between the shrouds and vanes.
  - The impeller is difficult to cast because the internal parts are hidden and hard to inspect for flaws.
  - The impeller is difficult to modify to improve its performance.
  - No impeller adjustment is possible. Once the wear ring clearances doubles they have to be replaced. This means the pump had to be disassembled just to check the status of the wear rings.
  - The closed impeller is a more complicated and expensive design not only because of the impeller, but the additional wear rings are needed.
Advantages and Disadvantages

- **Open Impeller**
  - Efficiency can be maintained through impeller clearance adjustment.
  - The impeller can be adjusted to compensate for wear and stay close to its best efficiency. No pump disassembly is necessary.
  - The open impeller is less likely to clog with solids, but if it does, it is easy to clean.
  - The open impeller has all the parts visible, so it's easy to inspect for wear or damage
  - The pump is less costly to build with a simple open impeller design.
  - The vanes can easily be cut or filed to increase the capacity.
  - You have a greater range of specific speed choices.
Pump Curve

- Flow rate vs. head
- Horsepower
- NPSH
- Efficiency
Pump & Plumbing Examples Good and Not So Good
Don’t Let Your Plumbing Get Out of Control!
Measurement

- Scales
- Meters
  - Flow rate
  - Accuracy
    - Quality control
    - Custody transfer
Types of Meters

- Positive Displacement
- Turbine/Squirrel cage
- Electromagnetic
- Coriolis Mass Flow
Positive Displacement

- Liquid moves into a measuring chamber and the number of “bites” are counted
- Volumetric
- Accuracy of some affected more than others by changes in product and flow.
- Lots of moving parts.
Turbine Meters

- Volumetric
- Liquid moving through meter causes rotor to turn in proportion to flow rate
- Straight pipe requirement
  - Inlet 20X pipedia – outlet 10X pipedia
- Changes in flow rate and viscosity can have large effect on accuracy
- Some moving parts
“Mag” Meters

- Volumetric.
- Measures velocity of liquid through a tube of known area.
- Liquid must be electrically conductive.
- Highly accurate across large range of flow rates and viscosities.
- Less straight pipe needed.
- No moving parts to wear out.
Mass Flow Meters

- Measures mass or weight.
- Some accurate to .10% of flow rate.
- Doesn’t care what liquid it’s measuring.
- High turndown ratio.
- Only moving parts are oscillating tubes.
Calibrate!

- All meters can lose calibration over time
- Mechanical types more susceptible to wear
  - Flow rate
  - Compatibility
- If calibrating volumetric meters by weight, know the true density of the product.
Controlling the Flow

- Valves
- Manifolds
- Control systems
Valve Selection

- Style
- Construction
- Operation
Types of Valves

- Ball valves
- Butterfly valves
- Gate valves
- Check valves
Control Systems

- Manual
- Actuated valves
- Presets
- Automation
MEI Fusion Preset

- Easy to read LCD Display, even in bright sunlight
- Print function with time & date
- Adjustable pre-act, compensates for product over-runs
- Corrosion resistant, NEMA 4X, FRP – 12:X14” enclosure
- Pre-wired, easy to install
- Compatible with most meters
- Direct upgrade replaceable for existing MEI Preset Controls
- Programmable Display
  - Total
  - Flow Rate Preset
  - Products ID’s
Control Systems

- Manual
- Actuated valves
- Presets
- Automation
Mix Systems

- Custom design – purpose built
- Tons per day required
  - small custom blends
- Truck load quantities
- Push products into mix tanks
- Rely on plant pump to draw products
- 1,000 tons per day – sure all liquids pumped & metered – use dump pit
Organize your work, utilize your plan and you’ll avoid making a mess!

Thank you