Irrigation Basics for Landscape Irrigation Contractors – LSU AgCenter

Irrigation Hydraulics

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Water Fundamentals: Variables and Units

- Cross sectional area of a pipe
  \[ A = \pi \times r^2 \]
  \[ A = \pi \times \frac{d^2}{4} \]

Water Fundamentals: Weight, Pressure, and Volume

- Water
  - 8.34 lbs/gallon
  - 7.48 g/ft³
  - 62.4 lbs/ft³
  - 1000 kg/m³

Water Fundamentals: Weight and Pressure

- Water exerts a force on its surrounding
- Pressure: psi (lbs/in²), kPa, bars
  - 2.31 ft of water provides 1 psi
  - 23.1 ft of water provides 10 psi
  - 1 ft of water provides 0.433 psi
- Elevation (ft) = pressure (2.31 ft/psi)
- Metric: 1 m of water = 9.81 kPa

Water Fundamentals: Weight and Pressure

- Static Pressure
  - Pressure in a system when water is motionless
  - Will vary at different locations in system due to differences in elevation
- Dynamic Pressure
  - “Operating” or “Working” pressure
  - Pressure exiting any point in a system when it is operating
  - \( DP < SP \) due to resistance and friction losses

Water Fundamentals: Flow

- Velocity is the speed of water as it moves through a pipe system. We use “average” velocity (feet per second, fps, ft/s, m/s).
  \[ 1 \text{ ft/s} = 0.305 \text{ m/s} \]
- Flow (flowrate) is a measure of the amount of water moved during a period of time (gallons per minute, gpm, ft²/s, m³/s).
  \[ 1 \text{ ft}^2/\text{s} = 449/\text{gpm} \]
Water Fundamentals: Flow

- Relationship between velocity, flow, cross-sectional area of a pipe:
  \[ q = va \]

  \[ q = 2.448 \times v \times D^2 \]

  \( q \) in gpm; \( v \) in ft/sec; \( D \) in in

- Example: Schedule 40 pipe, 2” nominal pipe size (NPS), 3 feet per second. What is the flowrate in gpm?

  \[ q = 3 \text{ ft/s} \times 60 \text{ s/min} \times \pi \times (2/2)^2 \text{ in}^2 \times 1 \text{ ft}^2/144 \text{ in}^2 \]

  \[ q = 3 \times 60 \times 3.14 \times 1/160.00694 \]

  \[ q = 3.92 \text{ ft}^3/\text{min} \]

  \[ q = 3.92 \text{ ft}^3/\text{min} \times 7.48 \text{ gal/ft}^3 \]

  \[ q = 29.3 \text{ gpm} \]

Water Fundamentals: Flow - Class Problem: Schedule 40 pipe, 4 feet per second. What is the flowrate in gpm at the following pipe sizes?

- 1” =  
- 1 ¼” =  
- 1 ½” =  
- 2” =  

Water Fundamentals: Energy

- Energy Head = the amount of energy associated with the combination of elevation, pressure, and velocity

  \[ H(\text{ft}) = p\text{ (psi)} \times 2.31 \text{ ft/(1 lb/sq.in.)} + E\text{ (ft)} \]

- Neglecting velocity head (small contribution):

  \[ H(\text{ft}) = p\text{ (psi)} + E\text{ (ft)} \]

Water Fundamentals: Friction Loss

- Water flowing in pipes loses energy

- Any change in flow, restriction, causes of additional turbulence, etc., will result in a decrease in energy

- Factors affecting friction loss
  - velocity
  - pipe diameter
  - pipe roughness (type)
  - length

Water Fundamentals: Friction Loss - Velocity Affects

- Maximum?
- Minimum?

- Recommended ranges of velocities in plastic pipe?

- Costs:
  - 1 in. diameter PVC
    - Schedule 40 (450 psi) $7.00/20 ft
    - Thin wall (315 psi) $3.60/20 ft
    - 49% reduction in cost
Pressure loss due to pipe length

<table>
<thead>
<tr>
<th>Height in feet</th>
<th>92.4'</th>
<th>90.1'</th>
<th>87.8'</th>
<th>85.5'</th>
<th>83.2'</th>
<th>80.9'</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLOW</td>
<td>0 psi</td>
<td>10 psi</td>
<td>20 psi</td>
<td>30 psi</td>
<td>40 psi</td>
<td>50 psi</td>
</tr>
</tbody>
</table>

What's the effect of 1 psi loss per 100 feet?

Friction & Velocity Charts

Every shape and style!!!

Friction & Velocity Charts (Choate, Page 388)

1-1/2 Sch 40 at 15 gpm = 0.669 psi loss/100 ft

Water Hammer

- Water hammer occurs when the flow of water in a pipe is abruptly changed or stopped
- When water hammer occurs, a high intensity pressure wave travels back through the piping system until it reaches a “point of relief”
  - valve, sprinkler, elbow, poor glued joint, stressed pipe

Causes of water hammer

1. Valve closure
2. Uncontrolled flow velocity in empty pipes
3. Trapped air in long runs of pipe
4. Reverse flow when pumps stop

Avoiding water hammer

- 5 ft/s maximum design
- Thrust blocking
- Air relief valves
- Check valves
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