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Drip Tubing Hydraulics During Pressurization

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**Drip Tubing Hydraulics During Pressurization**

- Subsurface wastewater dispersal using drip irrigation techniques
  - Advantages
    - application of effluent is about 1/2 gallon per hour per emitter
    - pressure-compensated emitters provide tremendous uniformity across field
    - can be installed without massive soil disturbance
    - with dosing and resting, can control soil moisture for aerobic and anaerobic microbial activity
Drip Tubing Hydraulics During Pressurization

• Subsurface wastewater dispersal using drip irrigation techniques
  – Disadvantages
    • effluent must be filtered before tubing
    • tubing must be forward flushed to scour biological growth
    • not very forgiving
System Design

• Relatively easy
  – match application rate to the soil type
    • average daily application rate
    • instantaneous application rate
  – ensure that pump and supply-piping can provide the minimum pressure for the emitters
  – install tubing on contour
  – each dose should last long enough to make the non-steady state time insignificant compared to the steady state time
Steady State Operation

• System is at design pressure and producing water at the design rate
• How much time is required from pump-start to steady state?
  – volume within supply piping
  – volume within tubing
  – flow rate of pump
  – volume emitted once water enters tubing
Thus, the Questions

• how much water is emitted
  – during tubing pressurization?

• on a given length of tubing,
  – is the water volume produced by the first set of emitters significantly different than the last emitters?

• in a marginal soil,
  – would this difference cause surfacing of effluent?
Measurements

• Volume
  – water meter
    • 0.1 gallon precision
    • used stop watch and datalogger to get flow rate

• Pressure
  – indication of pressure build up and friction loss
    • pressure transducers every 50 feet
    • pressure measured in one-second intervals with datalogger
Laboratory Procedure

• Read meter
• Begin “dose”
  – open ball valve
  – start stop watch
• Wait for tubing to fill
  – air/vacuum valve “snaps” at distal end
    • stop timer
    • read meter
    • close valve
• Three replications
Data Collected

• Volume
  – volume of water required to fill tube

• Time
  – time required to fill tube

• Calculations
  – average flow rate
  – average velocity within tubing
Tubing

• Geoflow
  – Wasteflow PC
  – 0.53 gph per emitter, 24-inch emitter spacing
  – internal diameter 0.55”

• Netafim
  – Bioline PC
  – 0.63 gph per emitter, 24-inch emitter spacing
  – internal diameter 0.57”
Tubing and Friction

• Test lengths
  – 100, 200, 300, 400, 500, & 600 feet

• Pressure transducers
  – before ball valve on supply side
  – beginning of tubing
  – every 50 feet
  – distal end
  – 100-foot test had 4 pressure transducers
  – 300-foot test had 8 pressure transducers
Remember
This is not a Comparison

• The tubing is not a variable in this study
  – we collected information about the two types of tubing
  – this information is needed to understand the non-steady state component of drip design
  – this information is lacking in the literature of both manufacturers
Example Output
# Time and Velocity

Table 1. Average in-flow rates and water velocities in tubing during pressurization.

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Length (ft)</th>
<th>Mean Pressurization Time (sec)</th>
<th>Mean Flow Rate (gpm)</th>
<th>Average Velocity (fps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geoflow</td>
<td>100</td>
<td>13</td>
<td>5.9</td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>29</td>
<td>5.2</td>
<td>6.9</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>57</td>
<td>4.3</td>
<td>5.3</td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>93</td>
<td>4.1</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>140</td>
<td>3.7</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>201</td>
<td>3.7</td>
<td>3.0</td>
</tr>
<tr>
<td>Netafim</td>
<td>100</td>
<td>11</td>
<td>7.4</td>
<td>9.4</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>26</td>
<td>6.5</td>
<td>7.6</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>47</td>
<td>6.0</td>
<td>6.4</td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>69</td>
<td>5.4</td>
<td>5.8</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>100</td>
<td>5.2</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>141</td>
<td>5.0</td>
<td>4.3</td>
</tr>
</tbody>
</table>
# Volume to Fill Tubing

Table 2. The volume of water required to fill the tubing as compared to the tubing volume is listed for various lengths of tubing.

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Length (ft)</th>
<th>Average Volume Required to Fill Tubing (gal)</th>
<th>Volume of Tubing based on Length and Diameter (gal)</th>
<th>Estimated Volume Emitted during Pressurization (gal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Netafim</td>
<td>100</td>
<td>1.3</td>
<td>1.33</td>
<td>below detection*</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>2.9</td>
<td>2.66</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>4.7</td>
<td>3.99</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>6.1</td>
<td>5.32</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>8.7</td>
<td>6.65</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>11.7</td>
<td>7.98</td>
<td>3.7</td>
</tr>
<tr>
<td>Geoflow</td>
<td>100</td>
<td>1.2</td>
<td>1.23</td>
<td>below detection</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>2.5</td>
<td>2.46</td>
<td>below detection</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>4.1</td>
<td>3.69</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>6.3</td>
<td>4.92</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>8.6</td>
<td>6.15</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>12.4</td>
<td>7.38</td>
<td>5.0</td>
</tr>
</tbody>
</table>

* The resolution of the water meter was 0.1 gallon
Emission Volume before Full Pressurization

• Using the Netafim results as an example
  – the emitted volume of 200 feet of tubing is only about seven percent of the tubing volume
  – for a 600-foot length, the emitted volume is approximately 46% of the tubing volume.
Timing Along Length

Geoflow 200' Trial 2

Pressure (psi)

Time (sec)

PT 1
PT 2
PT 3
PT 4
PT 5
PT 6
Pressurization Wave

- It is reasonable to expect the water wave velocity to decrease exponentially with lateral length
  - The friction head will increase with length and flow from the pump decreases exponentially with an increase in head (pressure)
  - a function of the pump’s performance curve
Instantaneous Velocities

- 200-foot length of Geoflow tubing
  - the velocity was approximately 9 fps in the first 50 feet,
  - 8 fps in the second 50 feet
  - 6 fps in the third 50 feet
  - 5 fps in the last 50 feet
  - Overall the average fill time was 29 seconds to move 200 feet or 6.9 fps.
Scour during Pressurization

• These pressurization velocities are greater than 2 fps (a widely recognized scour velocity)
  – It is likely that solids within the tubing will be progressively moved to the distal end with each dosing cycle
  – This effect improves the effectiveness of the periodic forward-flush of the drip laterals
Emitter Location and Operating Pressure

Netafin 500' Trial 2

Pressure (psi) vs. Time (sec)

Lines represent different pressure transducers (PT 1 to PT 12).
Pressure on Proximal Emitters

• As the water wave passes each emitter
  – the velocity head and friction head (energy required to move the wave forward) is converted into a static pressure that will force water out of the emitters
  – This “back pressure effect” increases with the tubing length.
Once the Wave Passes the Emitter

- The near-end emitters will be at operating pressure before the distal emitters receive water
  - the design minimum operating pressure for Geoflow and Netafim is seven and five pounds per square inch, respectively.
  - the emitters within the first 50-foot segment are already at operating pressure a full 45 seconds before the emitters located in the last 50-foot segment of a 300-foot Netafim tube.
Significantly Different?

<table>
<thead>
<tr>
<th>Length</th>
<th>Time (sec)</th>
<th>First Emitter Volume (gal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>13</td>
<td>0.002</td>
</tr>
<tr>
<td>200</td>
<td>29</td>
<td>0.004</td>
</tr>
<tr>
<td>300</td>
<td>57</td>
<td>0.008</td>
</tr>
<tr>
<td>400</td>
<td>93</td>
<td>0.014</td>
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<tr>
<td>500</td>
<td>140</td>
<td>0.021</td>
</tr>
<tr>
<td>600</td>
<td>201</td>
<td>0.029</td>
</tr>
</tbody>
</table>

Geoflow tubing (0.53 gph/emitter)
## Five Minute Dose

<table>
<thead>
<tr>
<th>Length</th>
<th>First Emitter (gal)</th>
<th>Last Emitter (gal)</th>
<th>Percent Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>0.044</td>
<td>0.042</td>
<td>-4.5</td>
</tr>
<tr>
<td>200</td>
<td>0.044</td>
<td>0.040</td>
<td>-9.1</td>
</tr>
<tr>
<td>300</td>
<td>0.044</td>
<td>0.036</td>
<td>-18</td>
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<tr>
<td>400</td>
<td>0.044</td>
<td>0.030</td>
<td>-32</td>
</tr>
<tr>
<td>500</td>
<td>0.044</td>
<td>0.024</td>
<td>-46</td>
</tr>
<tr>
<td>600</td>
<td>0.044</td>
<td>0.015</td>
<td>-66</td>
</tr>
</tbody>
</table>

Geoflow tubing (0.53 gph/emitter)
## Ten Minute Dose

<table>
<thead>
<tr>
<th>Length</th>
<th>First Emitter (gal)</th>
<th>Last Emitter (gal)</th>
<th>Percent Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>0.088</td>
<td>0.086</td>
<td>-2.3</td>
</tr>
<tr>
<td>200</td>
<td>0.088</td>
<td>0.084</td>
<td>-4.5</td>
</tr>
<tr>
<td>300</td>
<td>0.088</td>
<td>0.080</td>
<td>-9.1</td>
</tr>
<tr>
<td>400</td>
<td>0.088</td>
<td>0.074</td>
<td>-16</td>
</tr>
<tr>
<td>500</td>
<td>0.088</td>
<td>0.068</td>
<td>-23</td>
</tr>
<tr>
<td>600</td>
<td>0.088</td>
<td>0.059</td>
<td>-33</td>
</tr>
</tbody>
</table>
### Netafim tubing (0.62 gph)

<table>
<thead>
<tr>
<th>Length</th>
<th>Percent Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5-min dose</td>
</tr>
<tr>
<td>100</td>
<td>-3.7%</td>
</tr>
<tr>
<td>200</td>
<td>-8.7%</td>
</tr>
<tr>
<td>300</td>
<td>-16%</td>
</tr>
<tr>
<td>400</td>
<td>-23%</td>
</tr>
<tr>
<td>500</td>
<td>-33%</td>
</tr>
<tr>
<td>600</td>
<td>-47%</td>
</tr>
</tbody>
</table>
But, is this Significant?

• The proximal emitters (and soil) will receive the design dosage
  – the distal emitters (and soil) will receive less than design dosage
  – the longer the dose, the less difference

• If system is designed for the soil
  – then pressurization non-uniformity should not cause any surfacing of effluent
However,

- My assumptions are that the tubing is placed "on" or "very near" contour
  - Pressure compensated emitters are no excuse not to put the tubing on contour
  - until emitters are developed that will not allow discharge any water until operating pressure
    - then we still have to put the tubing on contour
    - and hydraulically isolate each lateral
Cuss and Discuss Time

http://onsite.tennessee.edu