This presentation premiered at WaterSmart Innovations

watersmartinnovations.com
Technology Working Group

Testing Protocols for Water Efficient Irrigation Technology

October 4, 2017
WaterSmart Innovations
FLOW SENSORS

Brent Mecham
CID, CLWM, CAIS, CIC, CLIA
Testing the flow sensor component only.

Not testing controllers and how they manage the inputs from the flow sensor
4.1 Flow meter

- A flow meter includes a sensing device for flow and can translate a signal into a readout to indicate either a flow rate or volume of water or both.

4.2 Flow sensor

- The instrument or device that detects the flow of water and transmits a signal to an indicating device that can store and display the volume or flow rate of the passing water.

- **Impeller-style flow sensor** utilizes a paddle-wheel impeller that is inserted into the piping system to detect or measure flow. The flow sensor produces an output signal of electrical frequency or pulses proportional to flow.
Flow sensors
Sizing

- Accommodate the range of flows they will measure, rather than match the size of the mainline pipe.
- Generally best practice is pipe velocity below 5 ft./s for the plastic piping.
- However, higher velocity in the sensor piping can increase accuracy.
- i.e. 3” mainline pipe but 2” flow sensor
## Sizing

<table>
<thead>
<tr>
<th>FLOW SENSOR MODEL</th>
<th>NOMINAL SIZE</th>
<th>FSI-T10-001</th>
<th>FSI-T15-001</th>
<th>FSI-T20-001</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Feet per Sec</td>
<td>1&quot;</td>
<td>1 1/2&quot;</td>
<td>2&quot;</td>
</tr>
<tr>
<td>Minimum Flow</td>
<td>0.25</td>
<td>0.86</td>
<td>1.8</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>3.5</td>
<td>7.24</td>
<td>11.3</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>7</td>
<td>14.5</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>10.4</td>
<td>22</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>17</td>
<td>36</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>24</td>
<td>51</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>35</td>
<td>72</td>
<td>113</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>42</td>
<td>87</td>
<td>136</td>
</tr>
<tr>
<td>Maximum Flow</td>
<td>15</td>
<td>52</td>
<td>108</td>
<td>170</td>
</tr>
</tbody>
</table>
Flow Sensors Installation

- To increase accuracy
  - Straight section of smooth, clean pipe
  - Avoid nearby fittings & components that cause turbulence
  - Flow sensor oriented at 12 noon—not tilted
Minimum requirements

- Flow direction
- 10 X Pipe Diameter
- 5 X Pipe Diameter
## Flow Sensor Comparison

<table>
<thead>
<tr>
<th></th>
<th>Accuracy full scale</th>
<th>Low flow</th>
<th>High flow</th>
<th>Upstream straight pipe diameters</th>
<th>Downstream straight pipe diameters</th>
<th>K value</th>
<th>Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>±3%</td>
<td>5</td>
<td>50</td>
<td>&gt;10</td>
<td>&gt;5</td>
<td>0.26112</td>
<td>1.2</td>
</tr>
<tr>
<td>B</td>
<td>±3%</td>
<td>5.4</td>
<td>54</td>
<td>&gt;10</td>
<td>&gt;5</td>
<td>0.26112</td>
<td>1.2</td>
</tr>
<tr>
<td>C</td>
<td>±3%</td>
<td>0.86</td>
<td>52</td>
<td>&gt;10</td>
<td>&gt;5</td>
<td>0.322</td>
<td>0.20</td>
</tr>
<tr>
<td>D</td>
<td>±3%</td>
<td>2</td>
<td>17</td>
<td>&gt;10</td>
<td>&gt;5</td>
<td>0.44</td>
<td>0.39</td>
</tr>
<tr>
<td>V</td>
<td>±2%</td>
<td>0.5</td>
<td>25</td>
<td>&gt;10</td>
<td>&gt;5</td>
<td>direct</td>
<td>read</td>
</tr>
</tbody>
</table>
Cost comparison?

Cost Comparison for 1-inch Flow Sensor

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>V</th>
<th>V+</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>191</td>
<td>269</td>
<td>325</td>
<td>176</td>
<td>238</td>
<td>303</td>
</tr>
</tbody>
</table>

Local data display only
Figure 1. Test Circuit for In-line Flow Sensors

- Water supply
- Shut-off Valve
- Pressure tap & pressure gauge
- Counting Device
- Flow Sensor
- 10d
- Shut-off Valve
- Reference Meter
- To drain or tank for recirculation
- Throttle Valve
- Temperature Sensor
Uniform Flow Upstream of 10D

Flow Rate, gpm

Flow Reading Error, %

0% 5% 10% 15%

0 2 4 6 8 10 12 14 16 18

Poly. (A) Poly. (B) Poly. (C)

Reference

A B C
Non-Uniform Flow Upstream of 10D

Flow Reading Error, % vs. Flow Rate, gpm

- A
- B
- C
- Reference
- V
- Poly. (A)
- Poly. (B)
- Poly. (C)
- Poly. (V)
Tilting the Flow Meter with Non-uniform Flow Conditions at 17.7 gpm

<table>
<thead>
<tr>
<th></th>
<th>Metron-Farnier 7040791</th>
<th>Metron-Farnier 7040792</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tilted 5 deg right</td>
<td>2.29 %</td>
<td>1.64 %</td>
</tr>
<tr>
<td>Tilted 5 deg left</td>
<td>1.73 %</td>
<td>0.33 %</td>
</tr>
<tr>
<td>Difference</td>
<td>0.56 %</td>
<td>1.30 %</td>
</tr>
</tbody>
</table>
Winterizing Flow Sensors

- Before freezing temperatures and/or blowing out sprinkler piping:
  - Remove sensor and safely store
  - Install plug in place of sensor

- Plastic bearing surfaces may melt from the excessive velocities of compressed air during winterization w/o water to cool/lubricate
## Test flow rate accuracy

<table>
<thead>
<tr>
<th>Sensor SN____________</th>
<th>Sensor size____________</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test flow rate</strong></td>
<td></td>
</tr>
<tr>
<td>Reference Meter Flow Rate gpm</td>
<td>Sensor Flow Rate gpm</td>
</tr>
<tr>
<td>Minimum flow rate</td>
<td></td>
</tr>
<tr>
<td>20% of maximum</td>
<td></td>
</tr>
<tr>
<td>40% of maximum</td>
<td></td>
</tr>
<tr>
<td>60% of maximum</td>
<td></td>
</tr>
<tr>
<td>80% of maximum</td>
<td></td>
</tr>
<tr>
<td>Maximum flow rate</td>
<td></td>
</tr>
</tbody>
</table>
## Durability tests

<table>
<thead>
<tr>
<th></th>
<th>PRESSURE $psi$</th>
<th>WATER TEMP $°F$</th>
<th>FLOW RATE $unit per minute$</th>
<th>OPERATING PERIOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous test</td>
<td>70</td>
<td>72</td>
<td>Q (80% of maximum)</td>
<td>10 hours</td>
</tr>
<tr>
<td>Cyclic test</td>
<td>70</td>
<td>72</td>
<td>Q (80% of maximum)</td>
<td>2,500 cycles</td>
</tr>
</tbody>
</table>
Environmental Test

- Flow sensor submerged for 30 days and tested for performance
- Simulate field conditions often encountered
THANK YOU

Get Involved

Brent Mecham: brentmecham@irrigation.org
Elizabeth McCartney: elizabethmccartney@irrigation.org
SWAT UPDATE

Promoting Smart Technologies and Efficient Irrigation Systems

Brian E. Vinchesi, Chair
October 4, 2017
Irrigation Show
SWAT’s Story

• Started in 2002, SWAT is a partnership initiative of water purveyors and irrigation industry representatives to promote landscape water-use efficiency through technology.
  • Promote irrigation products that improve water use efficiency—Promotions Working Group.
  • Write testing protocols to validate product performance—Technology Working Group.
SWAT Activities

- Protocols
- Testing Reports
- Marketing Resources
Protocol Development

- In place
  - Weather-based irrigation controllers
  - Soil moisture sensors
  - Rain sensors
  - Pressure regulating spray sprinklers
  - Check valves
  - Sprinkler nozzle performance characteristics
- SWAT protocols try to align with EPA WaterSense criteria, but not always
Sprinkler Application Efficiency

- SWAT still exploring a new way to measure sprinkler application (operational) efficiency
  - considers uniformity and off-target application
- Part of sprinkler nozzle efficiency protocol
  - Atmospheric losses
  - Jet interference
  - Overspray
  - Percolation losses
  - Coverage
- More testing with other then 15 foot spray nozzles need to be performed
Updating Testing Protocol/Reports

- ASABE standard X627
  - Weather-based Landscape Irrigation Control Systems
  - Based on SWAT protocol and considers EPA WaterSense labeling requirements
  - Proposed draft of standard is complete.
  - Beta testing being done to validate the test procedure before public comment period by CIT and Northern Colorado Water Conservancy District.
  - Funds needed to continue and expand Beta testing.
Test Report

Weather-Based Irrigation Controller Report

Manufacturer: XYZ Manufacturer
Controller: Awesome Model
Report Date: 9/28/2015

Test Dates (30-Day): 10/1/2014 - 10/30/2014
ET0: 3.12 in. Rainfall: 4.77 in.

Performance Summary

<table>
<thead>
<tr>
<th>Description</th>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
<th>Zone 4</th>
<th>Zone 5</th>
<th>Zone 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landscape ET (in.)</td>
<td>1.56</td>
<td>0.95</td>
<td>1.25</td>
<td>1.40</td>
<td>1.39</td>
<td>1.55</td>
</tr>
<tr>
<td>Effective ET (in.)</td>
<td>0.38</td>
<td>0.35</td>
<td>0.33</td>
<td>0.33</td>
<td>0.33</td>
<td>0.33</td>
</tr>
<tr>
<td>Days of Irrigation</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Effective Irrigation (in.)</td>
<td>1.34</td>
<td>1.36</td>
<td>1.72</td>
<td>2.34</td>
<td>1.25</td>
<td>1.33</td>
</tr>
<tr>
<td>Surplus (in.)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Irrigation Efficiency</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Scheduling Efficiency</td>
<td>100%</td>
<td>80%</td>
<td>100%</td>
<td>100%</td>
<td>0</td>
<td>90%</td>
</tr>
</tbody>
</table>

Controller Capabilities

User or Signal Fee: None
Watering Restrictions: None
Controlled Rainflow Management: Yes

Statement #1: Remote programming of controllers (a) via control system, (b) via control system and controller, (c) via internet and controller, (d) via internet and controller and/or controller API

Detailed Information: www.XYZManufacturing.com
Controller Models Using This Technology: Awesome 101 and Awesome 201
EPA WaterSense Labeled: Yes

www.irmigation.org/SWAT
## Performance Summary

### Weather-Based Irrigation Controller Report

**Manufacturer:** XYZ Manufacturer  
**Controller:** Awesome Model  
**Report Date:** 9/29/2015  
**Test Dates (30-Day):** 10/1/2014 – 10/30/2014  
**ETo:** 3.12 in.  
**Rainfall:** 4.77 in.

<table>
<thead>
<tr>
<th>Description</th>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
<th>Zone 4</th>
<th>Zone 5</th>
<th>Zone 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil</td>
<td>Loam</td>
<td>Silty clay</td>
<td>Loamy sand</td>
<td>Sandy loam</td>
<td>Clay loam</td>
<td>Clay</td>
</tr>
<tr>
<td>Plant material</td>
<td>Cool season grass</td>
<td>Warm season grass</td>
<td>Ground cover</td>
<td>Woody shrubs</td>
<td>Trees &amp; ground cover</td>
<td>Warm season grass</td>
</tr>
<tr>
<td>Exposure</td>
<td>75% shade</td>
<td>Full sun</td>
<td>Full sun</td>
<td>50% shade</td>
<td>Full sun</td>
<td>Full sun</td>
</tr>
<tr>
<td>Slope</td>
<td>6% slope</td>
<td>10% slope</td>
<td>8% slope</td>
<td>12% shade</td>
<td>2% slope</td>
<td>20% slope</td>
</tr>
<tr>
<td>Landscape ET (in.)</td>
<td>1.56</td>
<td>1.87</td>
<td>1.72</td>
<td>1.25</td>
<td>1.90</td>
<td>1.87</td>
</tr>
<tr>
<td>Effective Rainfall (in.)</td>
<td>1.34</td>
<td>1.30</td>
<td>1.28</td>
<td>1.34</td>
<td>1.96</td>
<td>1.35</td>
</tr>
<tr>
<td>Days of Irrigation</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Effective Irrigation (in.)</td>
<td>0.18</td>
<td>0.35</td>
<td>0.33</td>
<td>0.63</td>
<td>0.40</td>
<td>0.23</td>
</tr>
<tr>
<td>Surplus (in.)</td>
<td>0</td>
<td>0.02</td>
<td>0</td>
<td>0.1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Deficit (in.)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-0.02</td>
</tr>
<tr>
<td>Irrigation Adequacy</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>99%</td>
</tr>
<tr>
<td>Irrigation Excess</td>
<td>0%</td>
<td>6.8%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Scheduling Efficiency</td>
<td>100%</td>
<td>93.2%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

*Days of Irrigation* represents how many days irrigation was initiated during the test period.  
*Irrigation Adequacy* represents how well irrigation met the needs of the plant material. Research suggests that if this value is at least 80 percent, the vegetation will have acceptable health and appearance while conserving water.  
*Irrigation Excess* represents the application of irrigation water beyond the needs of the plant material. While no excess is desirable, reasonable expectations suggest no more than 10 percent excess for any zone and less than 5 percent overall.  
*Scheduling Efficiency* reflects how irrigation events avoided direct losses to runoff or exceeding root zone storage capacity.
**Controller Capabilities**

<table>
<thead>
<tr>
<th>User or Signal Fee</th>
<th>Watering Restrictions Compatible</th>
<th>Onsite Rainfall Management</th>
<th>Crop Coefficients Statements</th>
</tr>
</thead>
<tbody>
<tr>
<td>None-WiFi</td>
<td>Yes</td>
<td>Yes</td>
<td>Optional</td>
</tr>
</tbody>
</table>

**Statement #1:** Crop coefficient inputs are: (select most applicable statement)
- A) Neither used nor programmable.
- B) Not directly programmable but accounted for by the user in other scheduling parameters.
- C) Programmable for each station from a predetermined plant list.
- D) Programmable for each station from a predetermined plant list and customizable by user.
- E) Programmable for each station based on user knowledge and information.
- F) Programmable for each station using monthly variations from a predetermined list or customized by the user.

**Statement #2:** Remote programming of controller (select n/a, A, B or A & B statements)
- A) Crop coefficients are remotely programmable or updateable for a single controller
- B) Crop coefficients are remotely programmable or updateable for global application to numerous controllers

**Detailed Information:** [www.XYZmanufacturing.com](http://www.XYZmanufacturing.com)

**Controller Models Using This Technology:** Awesome 101 and Awesome 201

**EPA WaterSense Labeled:** Yes

www.irrigation.org/SWAT
Flow Sensor Protocol

• Version 3.0 – April 2017
• Responding to comments received
• 30 Day review period of Version 3.1 expected out for public comment in October
• Brent to discuss
Soil Moisture Sensors

- High priority
- Multiple rounds of Beta testing
- Beta testing is from a grant and administered by EBMUD—funds are depleted, but testing is not.
- EPA to elaborate as soon as I am done
Pressure Regulation Testing

- SWAT 2012
  - Continuous pressure increases
  - Step-test
  - Missing nozzle test
  - Focus on pressure measurements
- ASABE/ICC 802-2104 Standard
  - Continuous pressure increases
  - Missing nozzle test
- EPA WaterSense
  - Specification released September 21, 2017
- California Energy Commission
  - Exploring various methodologies
### Example from Catalog

<table>
<thead>
<tr>
<th>Pressure psi</th>
<th>Nozzle Flow gpm</th>
<th>Δ Pressure</th>
<th>Δ Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>2.85</td>
<td>-33.3%</td>
<td>-20.8%</td>
</tr>
<tr>
<td>30</td>
<td><strong>3.60</strong></td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>40</td>
<td>4.20</td>
<td>33.3%</td>
<td>+16.7%</td>
</tr>
<tr>
<td>50</td>
<td>4.58</td>
<td>66.6%</td>
<td>+27.2%</td>
</tr>
<tr>
<td>60</td>
<td>5.09</td>
<td>200%</td>
<td>+41.4%</td>
</tr>
<tr>
<td>70</td>
<td>5.50</td>
<td>233%</td>
<td>+52.8%</td>
</tr>
</tbody>
</table>
Issues

- ASABE/ICC 802-2014 standard now referenced in codes.
  - Pressure regulating sprinklers are mandatory.
- EPA did some evaluations.
  - The continuous test not a good test.
  - Step test is a better evaluation.
- SWAT is developing a revised test protocol.
- California Energy Commission is interested in the energy use as well as the water use.
- Market demand is increasing.
SWAT Protocol Changes

- Focus on step test procedure
- Measurements
  - At pressure
  - At increasing pressure steps 40, 50, 60, 75, maximum psi
- Measure flow based on incoming pressures or measure outlet pressures
- Test pop up sprays and rotors
- Added missing nozzle test
- With and without check valves
# Water Savings Calculations

## Low-flow Nozzle

<table>
<thead>
<tr>
<th>Pressure (psi)</th>
<th>Non PR gpm</th>
<th>PR-CV-F gpm</th>
<th>Δ</th>
<th>Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>1.13</td>
<td>1.08</td>
<td></td>
<td>4.6%</td>
</tr>
<tr>
<td>30</td>
<td>1.23</td>
<td>1.15</td>
<td></td>
<td>7.0%</td>
</tr>
<tr>
<td>40</td>
<td>1.41</td>
<td>1.21</td>
<td></td>
<td>16.5%</td>
</tr>
<tr>
<td>50</td>
<td>1.54</td>
<td>1.22</td>
<td></td>
<td>26.2%</td>
</tr>
<tr>
<td>60</td>
<td>1.69</td>
<td>1.26</td>
<td></td>
<td>34.1%</td>
</tr>
<tr>
<td>70</td>
<td>1.84</td>
<td>1.30</td>
<td></td>
<td>41.5%</td>
</tr>
</tbody>
</table>

Pressure-regulated sprinklers compared to non-pressure regulated sprinkler, but using same nozzles.
## Water Savings Calculations

### High-flow Nozzle

<table>
<thead>
<tr>
<th>Pressure psi</th>
<th>Non PR gpm</th>
<th>PR-CV-F gpm</th>
<th>Δ Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>3.271</td>
<td>3.050</td>
<td>7.2%</td>
</tr>
<tr>
<td>30</td>
<td>3.578</td>
<td>3.325</td>
<td>7.6%</td>
</tr>
<tr>
<td>40</td>
<td>4.113</td>
<td>3.497</td>
<td>17.6%</td>
</tr>
<tr>
<td>50</td>
<td>4.663</td>
<td>3.641</td>
<td>28.1%</td>
</tr>
<tr>
<td>60</td>
<td>5.058</td>
<td>3.695</td>
<td>36.9%</td>
</tr>
<tr>
<td>70</td>
<td>5.389</td>
<td>3.771</td>
<td>42.9%</td>
</tr>
</tbody>
</table>

Pressure-regulated sprinklers compared to non-pressure regulated sprinkler, but using same nozzles.
SWAT TWG—Going Forward

- Pressure regulating valves
- Scheduling programs/apps
Promoting Landscape Water-use Efficiency

- **Weather-based Controllers**
  - Weather-based controllers

- **Soil Moisture-based Controllers**
  - Using a probe buried in the soil

- **Rain Sensors**
  - Changing weather can quickly affect irrigation needs and lead to wasted irrigation. SWAT

- **Marketing Tools**
  - SWAT provides numerous tools and resources to help water providers promote water-use efficiency.
Literature

- Because Consumers /End-users are large audience water purveyors need a place to refer customers PWG developed the “Home Owner’s Guide to Landscape Irrigation”

- Discusses:
  - Planting
  - Proper design and Installation
  - Proper Maintenance
Volunteers

Representatives from water providers and the irrigation industry donate time and expertise to identify and implement strategic priorities.

Get Involved
THANK YOU

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