Impact of Supervisory Gas Pressure on Dry Pipe Sprinkler System Water Delivery Time

Steve Wolin
Director, Development and Compliance
Why Does Water Delivery Time Matter?

Delays application of water to fire
Allows fire to grow larger after activation
Limits system size
NFPA 13 Water Delivery Time Requirements

Systems protecting dwelling units: 15 s
Other systems: 60 s

Exceptions:

Systems up to 500 gal.: No Requirement
Systems up to 750 gal. with quick-opening device: No Requirement
OH, EH, and High Piled with multiple sprinklers open: 40-50 s

Shorter times required by specific design criteria

Water delivery time may be evaluated with a Listed calculation program or a test.
Factors Influencing Water Delivery Time

**NFPA 13**
- System volume
- Quick-opening device

**Actual**
- System volume
- Quick-opening device
- System configuration
- Supervisory pressure
- Trip pressure
- Water supply
- Sprinkler/test valve size

All other factors are evaluated based on performance by tests or calculations.
Components of Water Delivery Time

**Trip Time**
Time between opening sprinkler/test valve and dry pipe valve opening.

**Transit Time**
Time between dry pipe valve opening and water reaching sprinkler/test valve.
Differential Dry Pipe Valves (Conventional)

Simple design

Approx. ratio of 5.5:1

Typically, 40 psi min. supervisory pressure at 175 psi water supply pressure

Compressor/nitrogen generator sized based on anticipated leakage at supervisory pressure

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Low Pressure Dry Pipe Valve

- Smaller clapper reduces case size
- Variable ratio
- Typically, 18 psi min. supervisory pressure at 175 psi water supply pressure
- Reduces compressor/nitrogen generator size
- Less oxygen/moisture introduced into system
- Lower pressure to resist initial flow of water
Prior Work

The Fire Protection Research Foundation

Schirmer/Foundation Prior Work

Reviewed prior water delivery time studies
Solicited water delivery time data
Provided information on computer programs for calculating water delivery time
No direct comparison based on supervisory gas pressure
Prior Work

FM Global


Tyco Fire & Building Products

FM Global Prior Work

Provides equations to calculate trip time and transit time
Includes data for 40 sample systems
Suggests relationship between trip time and system volume
Identifies system configuration as primary factor influencing transit time
Other factors:
Static water pressure
Supervisory gas pressure
Conventional Pressure:
- Trip Time Formula: $0.016 \times \text{System Volume}$
- $R^2 = 0.369$
- Average $\Delta P = 16.2$ psi

Low Pressure:
- Trip Time Formula: $0.012 \times \text{System Volume}$
- $R^2 = 0.247$
- Average $\Delta P = 5.5$ psi

FM Global Data - Trip Time

- Graph showing data points for conventional and low pressure systems.
New Work

Experiments to investigate impact of supervisory gas pressure on water delivery time
Sample Systems

**Conventional Pressure**
Supervisory Press.: 40 psi
Trip Press.: 32 psi

**Low Pressure**
Supervisory Press.: 18 psi
Trip Press.: 12 psi

Which system trips faster?
Which system delivers water faster?
Overall Test Setup

4” nom. Mains
2” nom. Risers
1-1/2” nom. Branch Lines
Piping sloped 1/2“ per 10’

Key
- Sprinkler Fitting
- Control Valve
- Water Supply
Test Variables

**Trip Time**
Pipe configuration
- Short tree
- Long tree
- Loop
Sprinkler K-factor
- 8.0 gpm/psi$^{1/2}$
- 16.8 gpm/psi$^{1/2}$
Supervisory gas pressure/Trip pressure
- 18 psi/12 psi
- 40 psi/32 psi

**Transit Time**
Pipe configuration
- Short tree
- Long tree
- Loop
Sprinkler K-factor
- 8.0 gpm/psi$^{1/2}$
- 16.8 gpm/psi$^{1/2}$
Trip pressure
- 12 psi
- 32 psi
# Short Tree

<table>
<thead>
<tr>
<th>Pipe</th>
<th>Volume Total (gallons)</th>
<th>Volume Direct Path (gallons)</th>
<th>Distance (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mains</td>
<td>71.3</td>
<td>71.3</td>
<td>108.0</td>
</tr>
<tr>
<td>Risers</td>
<td>2.0</td>
<td>0.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Branch Lines</td>
<td>16.4</td>
<td>3.2</td>
<td>30.0</td>
</tr>
<tr>
<td>Total</td>
<td>89.7</td>
<td>74.7</td>
<td>139.2</td>
</tr>
</tbody>
</table>

**Key**
- Sprinkler Location
- Flow Direction
- Water Supply

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## Long Tree

<table>
<thead>
<tr>
<th>Pipe</th>
<th>Volume Total (gallons)</th>
<th>Volume Direct Path (gallons)</th>
<th>Distance (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mains</td>
<td>196.7</td>
<td>195.7</td>
<td>296.5</td>
</tr>
<tr>
<td>Risers</td>
<td>2.2</td>
<td>0.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Branch Lines</td>
<td>20.1</td>
<td>3.2</td>
<td>30.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>219.0</strong></td>
<td><strong>199.1</strong></td>
<td><strong>327.7</strong></td>
</tr>
</tbody>
</table>

### Key
- Sprinkler Location
- Flow Direction
- Water Supply

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## Loop

<table>
<thead>
<tr>
<th>Pipe</th>
<th>Volume Total (gallons)</th>
<th>Volume Direct Path (gallons)</th>
<th>Distance (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mains</td>
<td>196.7</td>
<td>196.7</td>
<td>298.0</td>
</tr>
<tr>
<td>Risers</td>
<td>2.2</td>
<td>0.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Branch Lines</td>
<td>20.1</td>
<td>3.2</td>
<td>30.0</td>
</tr>
<tr>
<td>Total</td>
<td>219.0</td>
<td>200.1</td>
<td>329.2</td>
</tr>
</tbody>
</table>

### Key
- Sprinkler Location
- Flow Direction
- Water Supply

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# Results

## Average Trip Time (seconds)

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Conventional Pressure</th>
<th>Low Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>3.5</td>
<td>4.5</td>
</tr>
<tr>
<td>K8.0 sprinkler</td>
<td>4.7</td>
<td>5.3</td>
</tr>
<tr>
<td>K16.8 sprinkler</td>
<td>2.3</td>
<td>3.7</td>
</tr>
<tr>
<td>Short tree</td>
<td>1.5</td>
<td>3.0</td>
</tr>
<tr>
<td>Long tree</td>
<td>4.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Loop</td>
<td>5.0</td>
<td>5.5</td>
</tr>
</tbody>
</table>
## Results

### Average Transit Time (seconds)

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Conventional Pressure</th>
<th>Low Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>30.2</td>
<td>25.8</td>
</tr>
<tr>
<td>K8.0 sprinkler</td>
<td>33.0</td>
<td>25.7</td>
</tr>
<tr>
<td>K16.8 sprinkler</td>
<td>27.3</td>
<td>26.0</td>
</tr>
<tr>
<td>Short tree</td>
<td>14.0</td>
<td>12.0</td>
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<tr>
<td>Long tree</td>
<td>41.5</td>
<td>35.0</td>
</tr>
<tr>
<td>Loop</td>
<td>35.0</td>
<td>30.5</td>
</tr>
</tbody>
</table>
## Results

### Average Water Delivery Time (seconds)

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Conventional Pressure</th>
<th>Low Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>33.7</td>
<td>30.3</td>
</tr>
<tr>
<td>K8.0 sprinkler</td>
<td>37.7</td>
<td>31.0</td>
</tr>
<tr>
<td>K16.8 sprinkler</td>
<td>29.6</td>
<td>29.7</td>
</tr>
<tr>
<td>Short tree</td>
<td>15.5</td>
<td>15.0</td>
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<tr>
<td>Long tree</td>
<td>45.5</td>
<td>40.0</td>
</tr>
<tr>
<td>Loop</td>
<td>40.0</td>
<td>36.0</td>
</tr>
</tbody>
</table>
Conclusions
Based on Test Setup

Water delivery time (CP: 33.7s vs LP: 30.3s)
Faster with Low Pressure

Dominated by Transit Time

Trip Time (CP: 3.5s vs LP: 4.5s)
Faster with Conventional Pressure

Transit Time (CP: 30.2s vs LP: 25.8s)
Faster with Low Pressure
Conclusions
Based on Test Setup

Sprinkler/Test Valve Orifice Size

Larger orifice reduces trip time
Larger orifice reduces transit time for Conventional Pressure
Larger orifice does not impact transit time for Low Pressure