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

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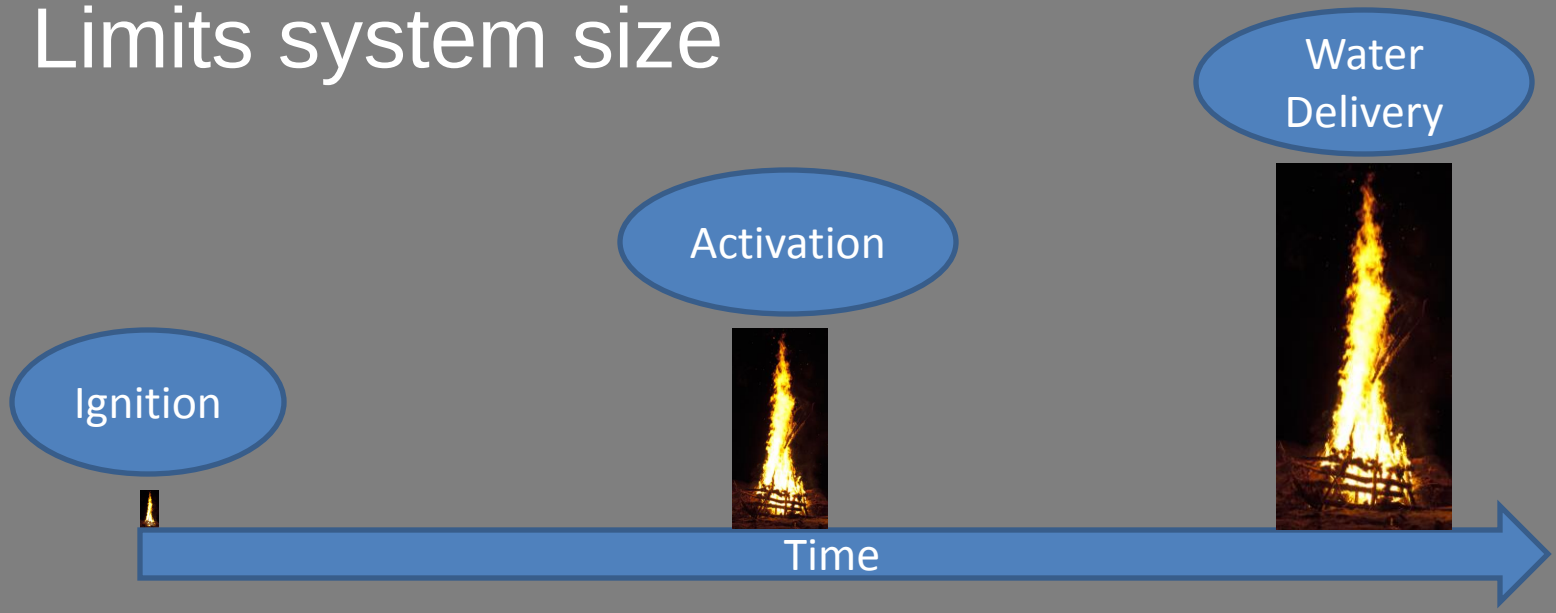
Why Does Water Delivery Time Matter?

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.

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Factors Influencing Water Delivery Time

NFPA 13

System volume

Quick-opening device

All other factors are evaluated based on performance by tests or calculations

Actual

System volume

Quick-opening device

System configuration

Supervisory pressure

Trip pressure

Water supply

Sprinkler/test valve size

Components of Water Delivery Time

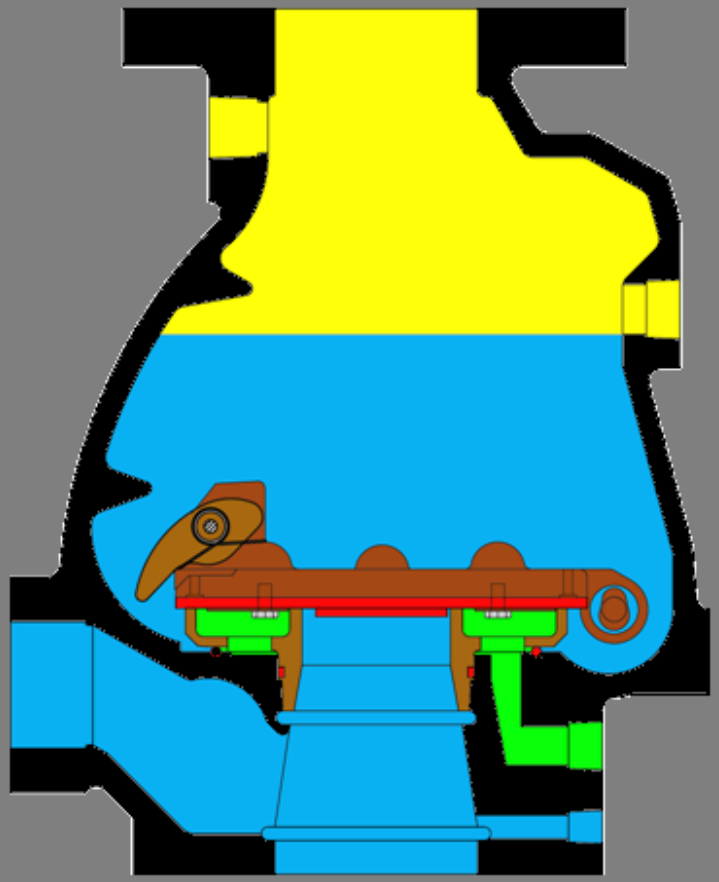
Trip Time

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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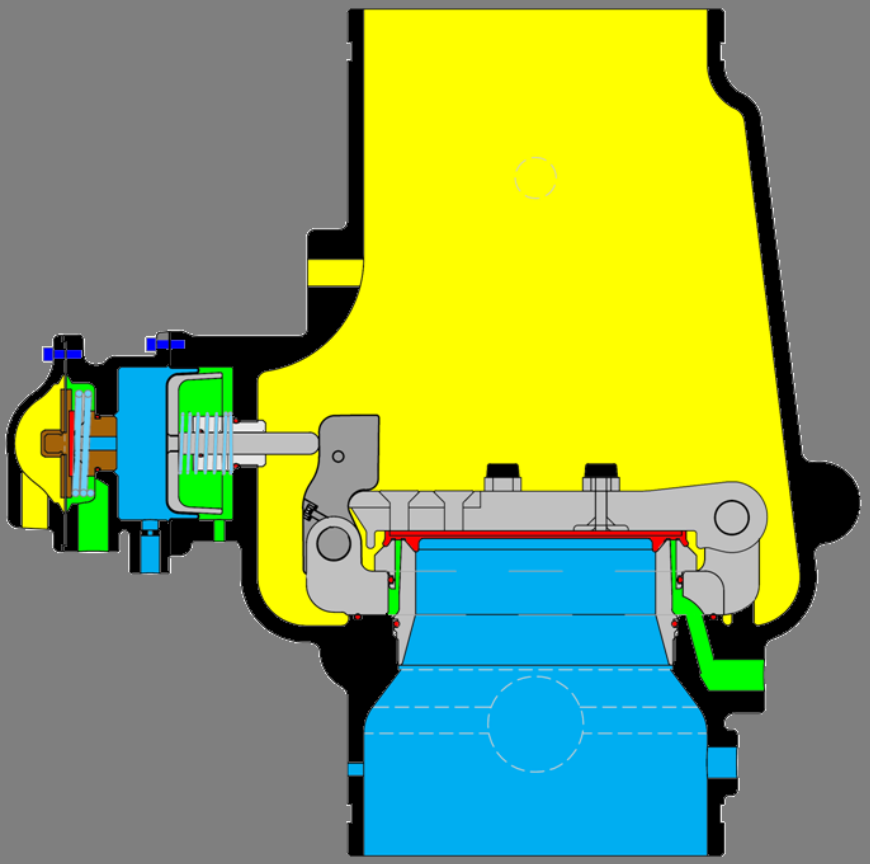
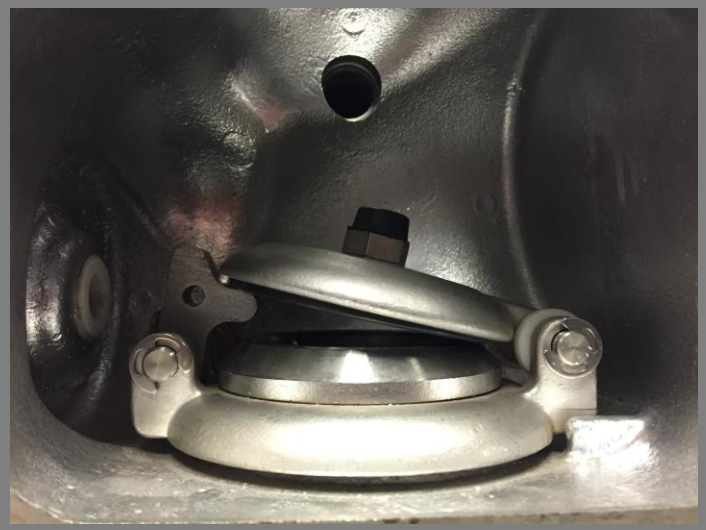
Low Pressure Dry Pipe Valve





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

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Prior Work

The Fire Protection Research Foundation

O'Connor, D.J., et al (Schirmer Engineering Corporation), "Supporting Data Needs for Automatic Sprinkler Committees Research Project: Review of NFPA 13 Dry System Water Delivery Provisions", The Fire Protection Research Foundation, Quincy, MA, 2007.

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

Heskestad, G., and Kung, H.C., “Transient Response of Dry-Pipe Sprinkler Systems,” Technical Report, Serial No. 15918, Factory Mutual Research Corporation, Norwood, MA, 1971.

Nam, S., “Design of Dry Pipe Sprinkler Systems to Meet the Water Delivery Time Restriction in Industrial Freezers,” Fire Safety Science-Proceedings of the Ninth International Symposium, IAFSS, 2008, pp. 491-502.

Tyco Fire & Building Products

Golinveaux , J.G., “A Technical Analysis: The Variables That Affect The Performance of Dry Pipe Systems,” Tyco Fire and Building Products, Lansdale, PA, 2002.

FM Global Prior Work

Provides equations to calculate trip time and transit time

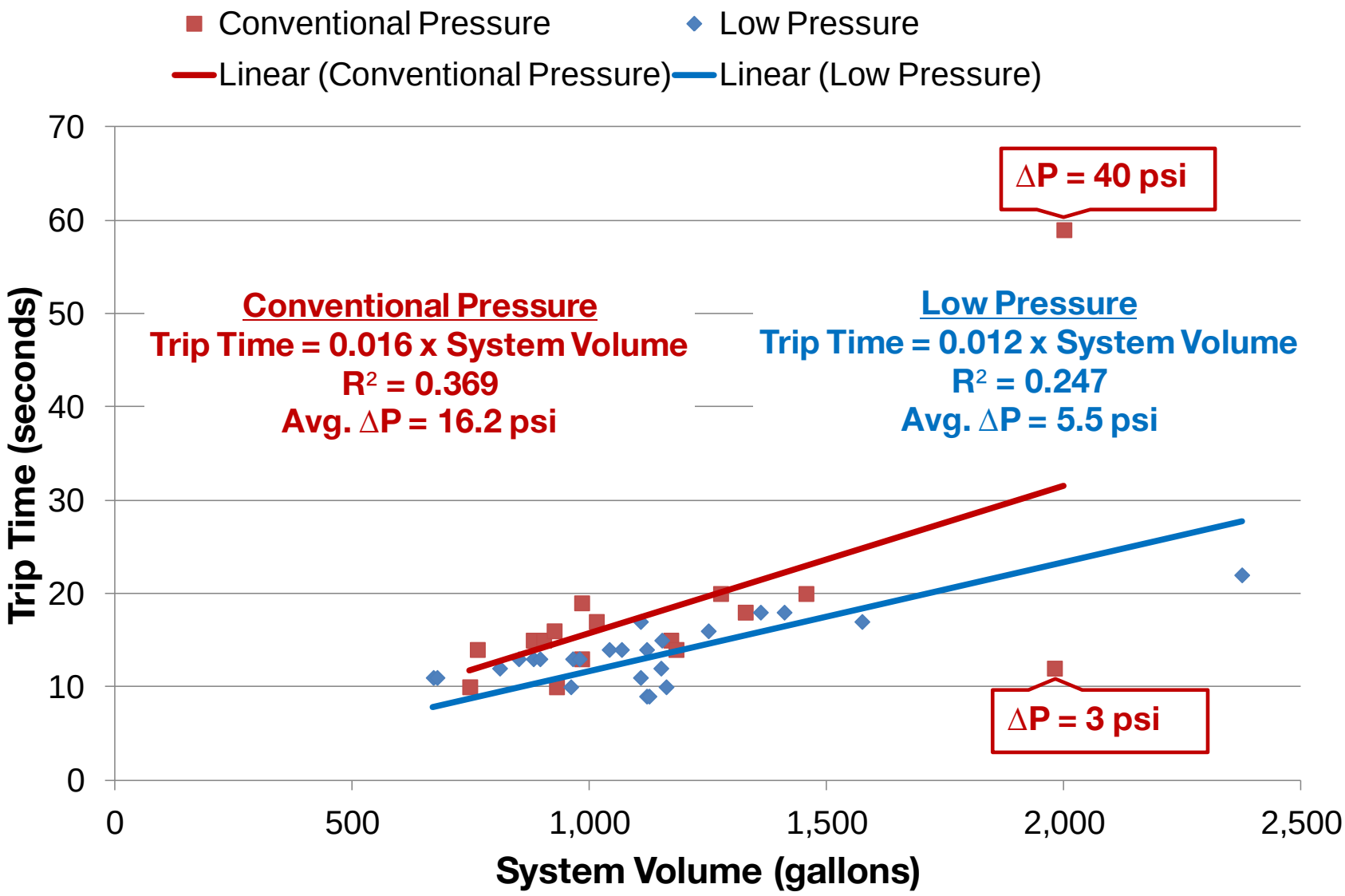
Includes data for 40 sample systems

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

FM Global Data - Trip Time



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?

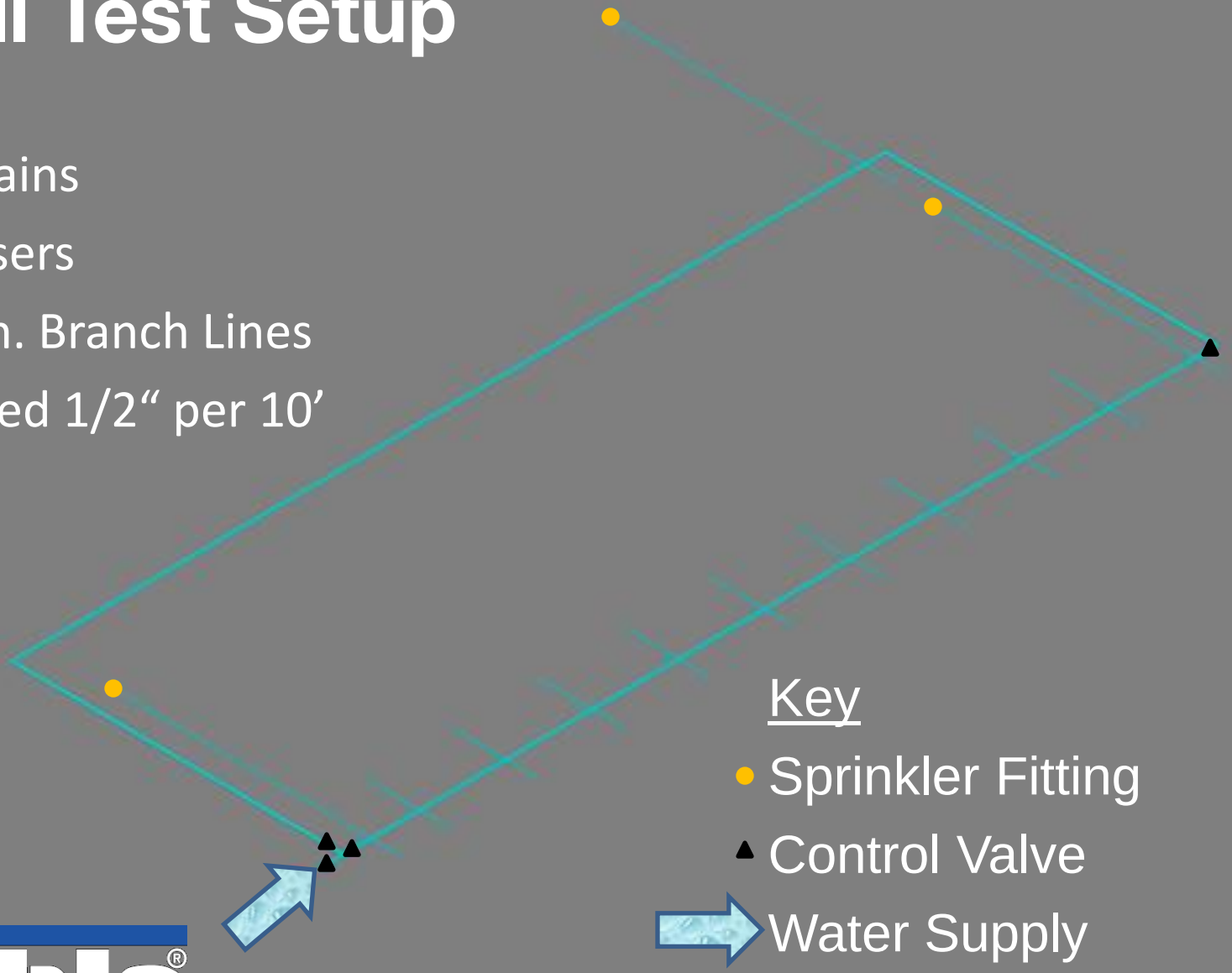
Overall Test Setup

4” nom. Mains

2” nom. Risers

1-1/2” nom. Branch Lines

Piping sloped 1/2“ per 10’



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

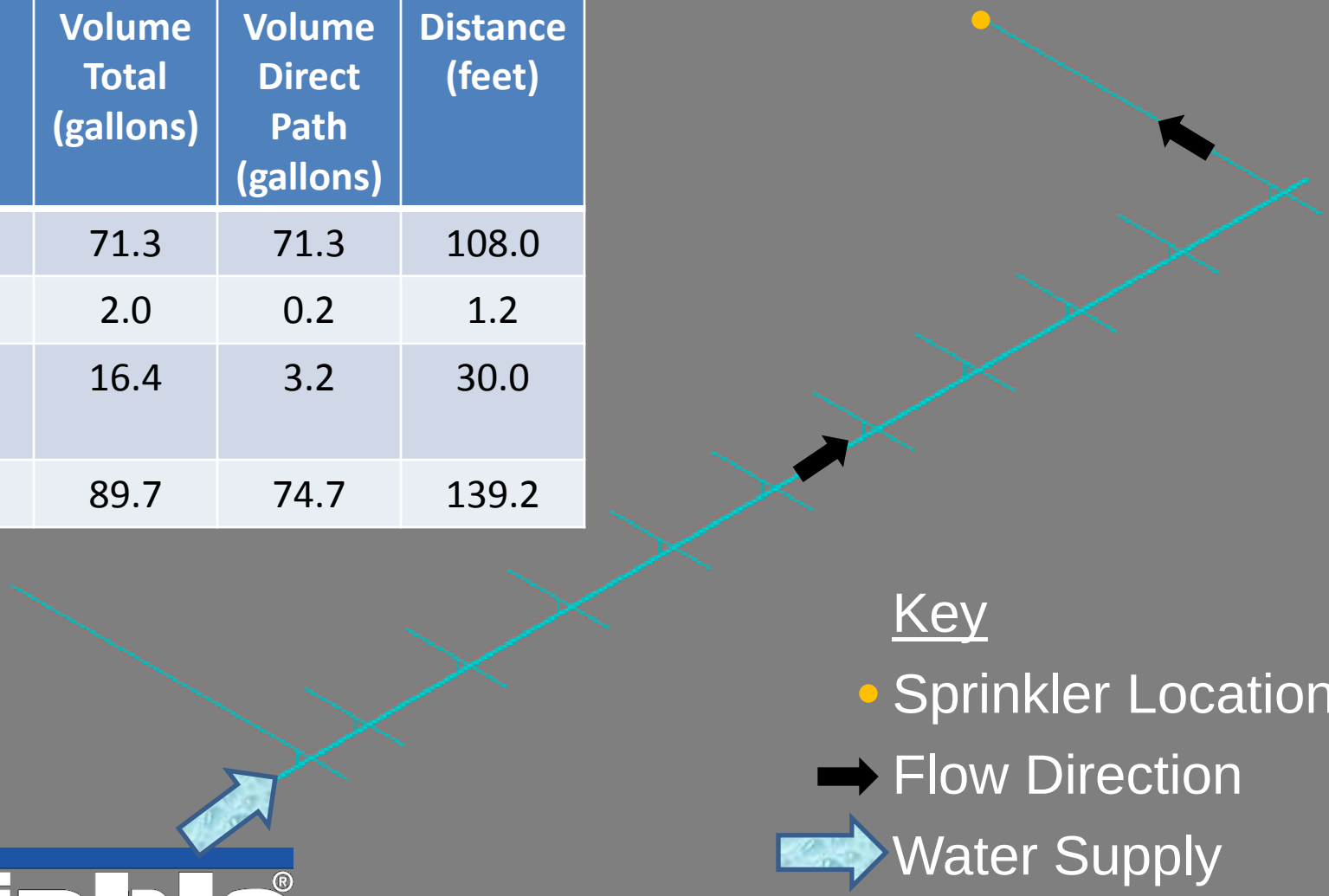
Pipe configuration
- Short tree
- Long tree
- Loop

Sprinkler K-factor
- 8.0 gpm/psi$^{1/2}$
- 16.8 gpm/psi$^{1/2}$

Trip pressure
- 12 psi
- 32 psi

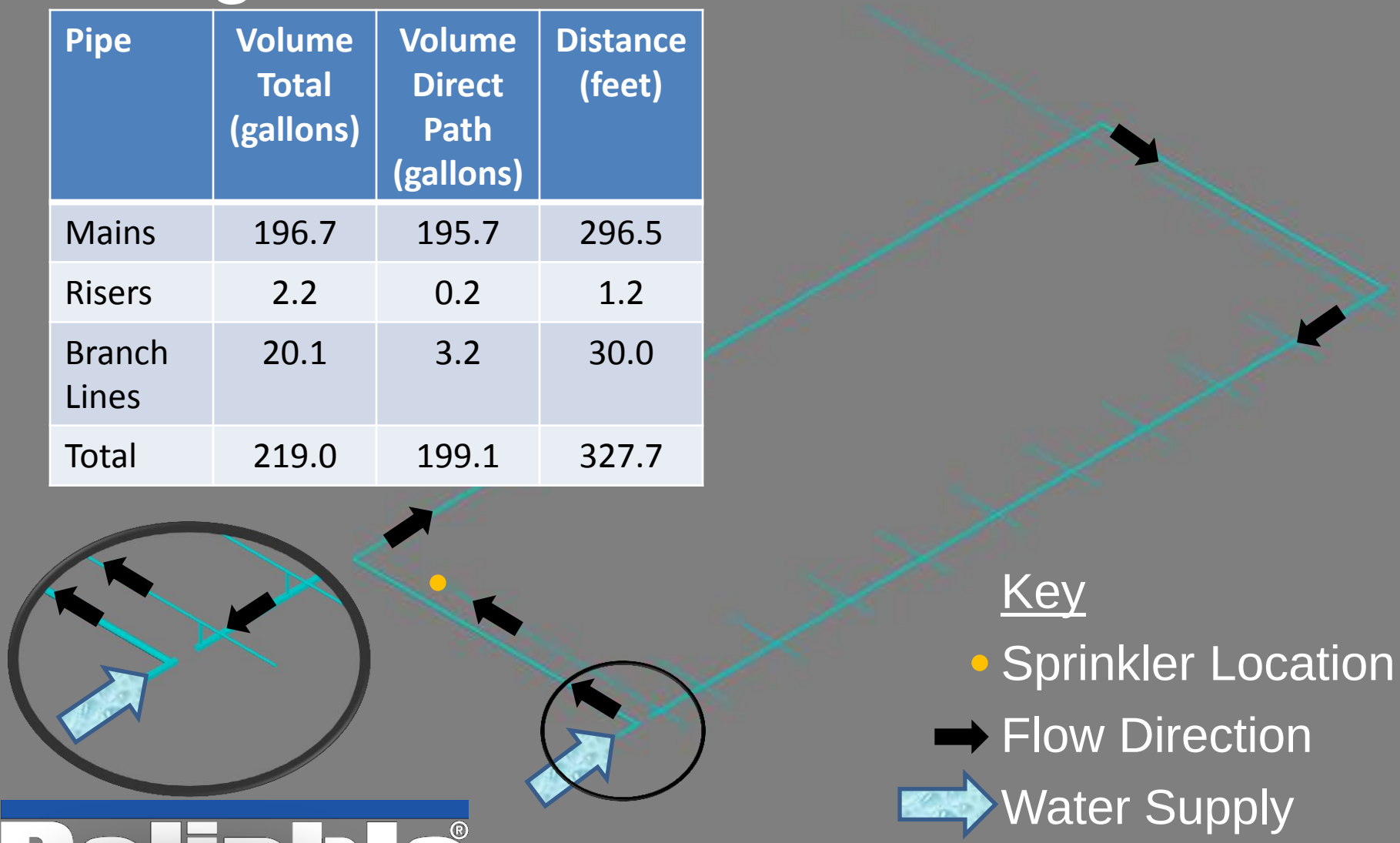
Short Tree

Pipe	Volume Total (gallons)	Volume Direct Path (gallons)	Distance (feet)
Mains	71.3	71.3	108.0
Risers	2.0	0.2	1.2
Branch Lines	16.4	3.2	30.0
Total	89.7	74.7	139.2



Long Tree

Pipe	Volume Total (gallons)	Volume Direct Path (gallons)	Distance (feet)
Mains	196.7	195.7	296.5
Risers	2.2	0.2	1.2
Branch Lines	20.1	3.2	30.0
Total	219.0	199.1	327.7

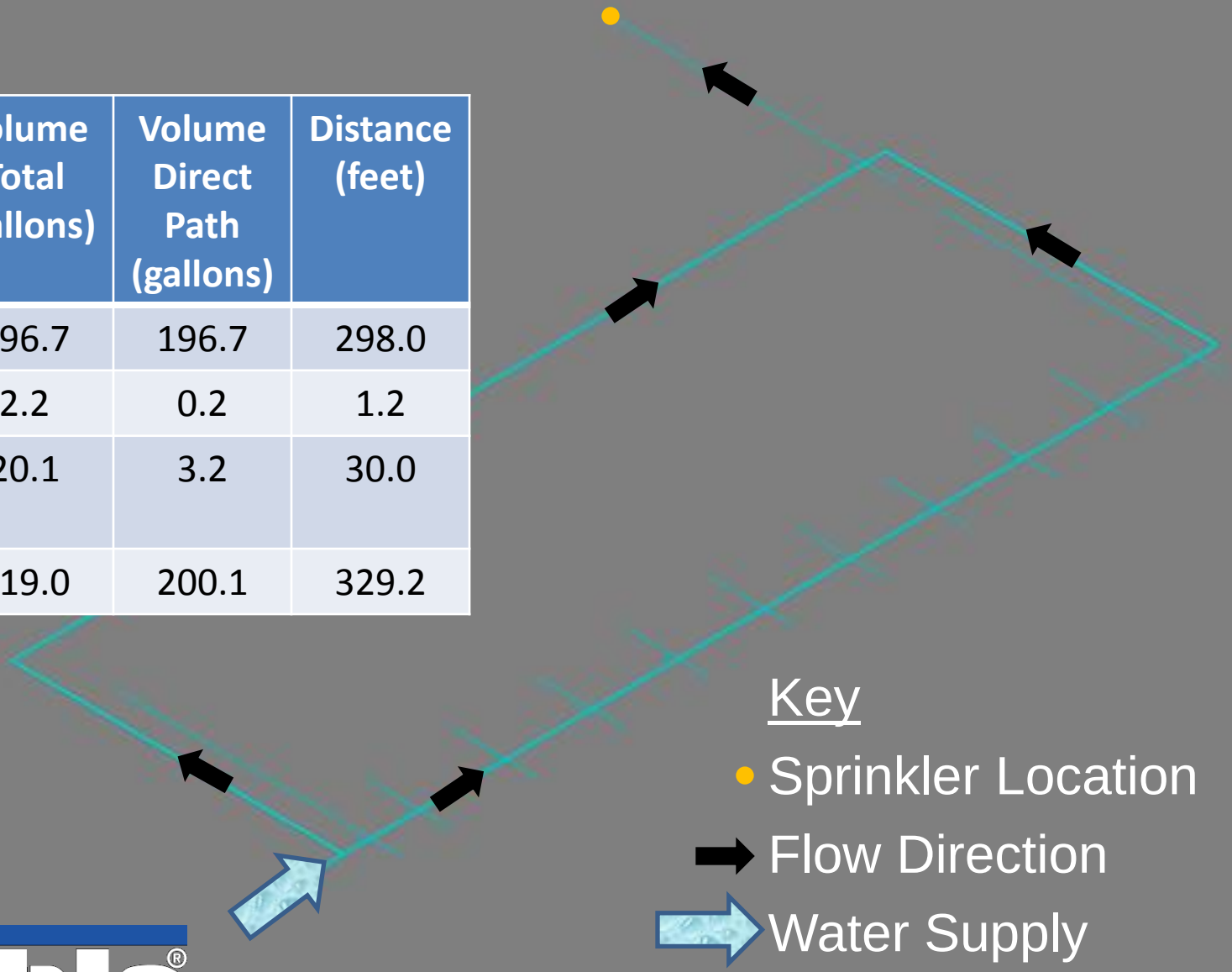


Key

- Sprinkler Location
- Flow Direction
- Water Supply

Loop

Pipe	Volume Total (gallons)	Volume Direct Path (gallons)	Distance (feet)
Mains	196.7	196.7	298.0
Risers	2.2	0.2	1.2
Branch Lines	20.1	3.2	30.0
Total	219.0	200.1	329.2



Results
Average Trip Time (seconds)

Configuration	Conventional Pressure	Low Pressure
All	3.5	4.5
K8.0 sprinkler	4.7	5.3
K16.8 sprinkler	2.3	3.7
Short tree	1.5	3.0
Long tree	4.0	5.0
Loop	5.0	5.5

Results
Average Transit Time (seconds)

Configuration	Conventional Pressure	Low Pressure
All	30.2	25.8
K8.0 sprinkler	33.0	25.7
K16.8 sprinkler	27.3	26.0
Short tree	14.0	12.0
Long tree	41.5	35.0
Loop	35.0	30.5

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Results
Average Water Delivery Time (seconds)

Configuration	Conventional Pressure	Low Pressure
All	33.7	30.3
K8.0 sprinkler	37.7	31.0
K16.8 sprinkler	29.6	29.7
Short tree	15.5	15.0
Long tree	45.5	40.0
Loop	40.0	36.0

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