Does Backflow Have Anything to do with Hydraulics
Paul H. Schwartz – USC FCCCHR
8 March 2012

UF/TREEO Conference

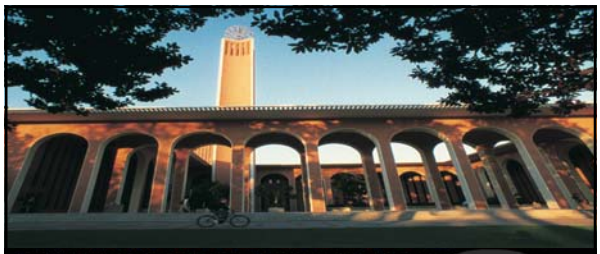
Does Backflow Have Anything to do with Hydraulics?

8 March 2012

USC Viterbi School of Engineering

Paul H. Schwartz, P.E.
Chief Engineer
Foundation for Cross-Connection Control and Hydraulic Research

USC



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Presentation

Does Backflow Have Anything To Do With Backflow?

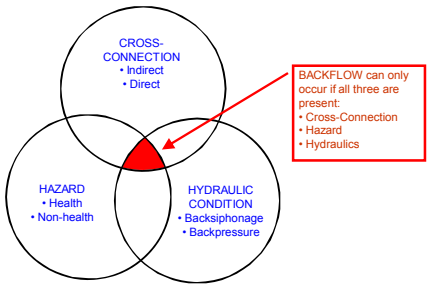
Communicate Effectively

- Consider your audience
- General knowledge of water distribution systems
- Previous misunderstandings

EPA Presentations – January 2008

- What we know about backflow
  - Including basic hydraulics animation
- What we don't know about backflow, and the research needs

Backflow Incident Requirements



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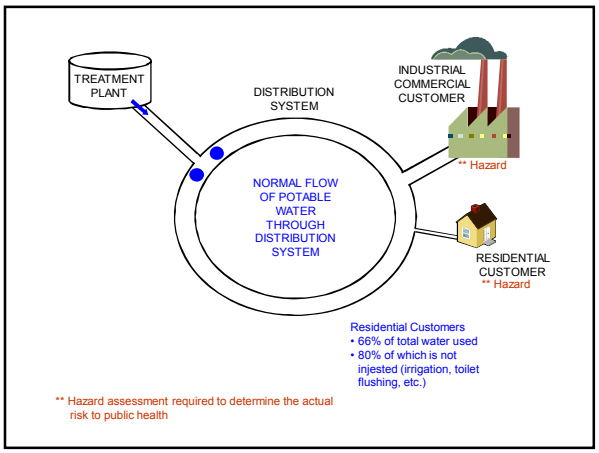
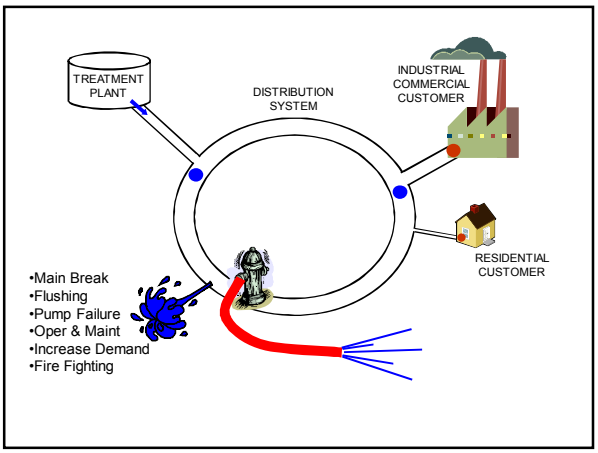
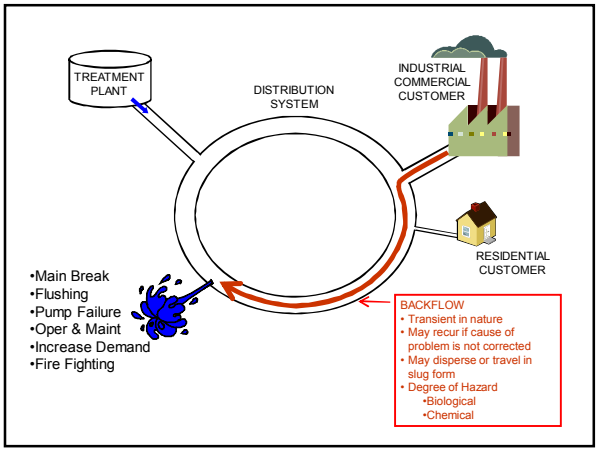
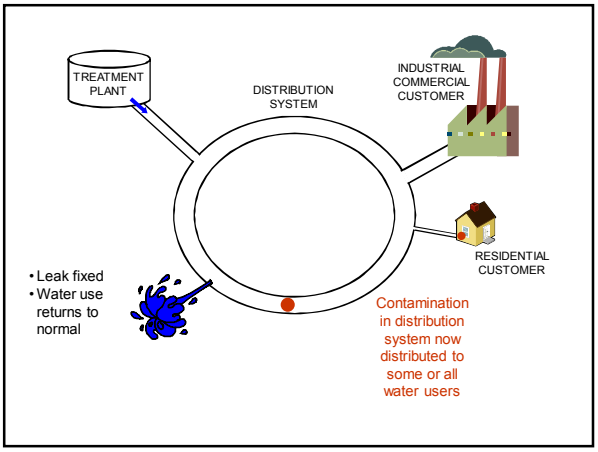
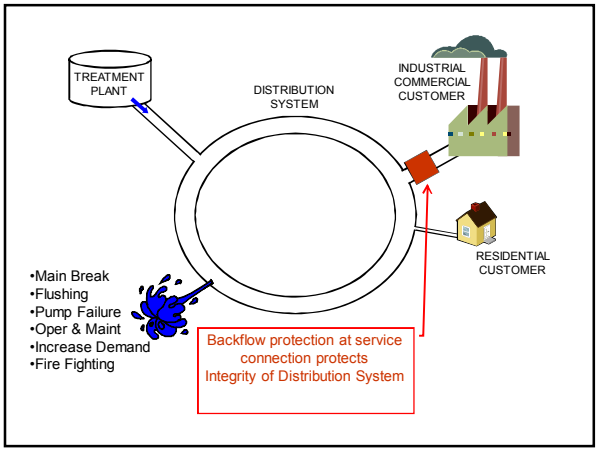
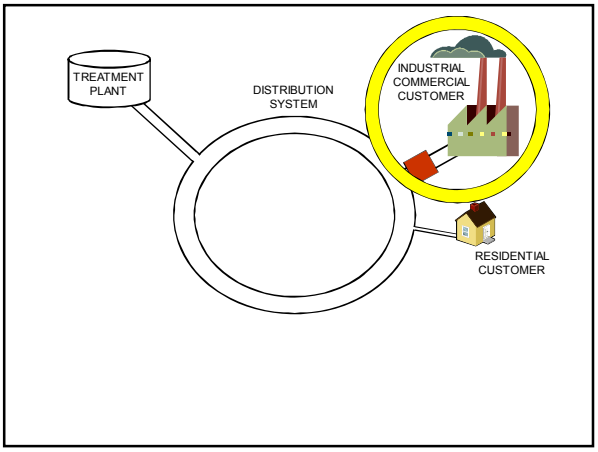


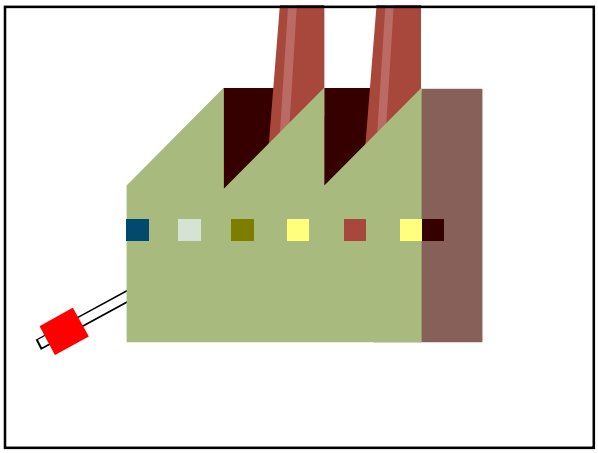


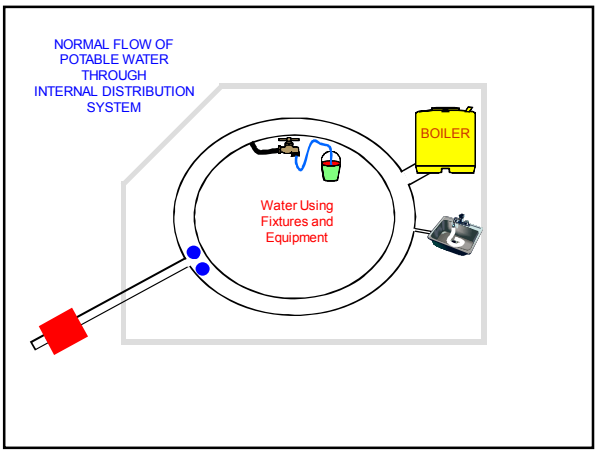


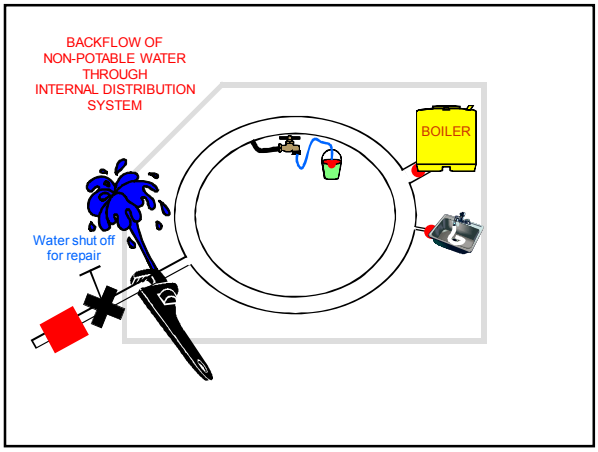


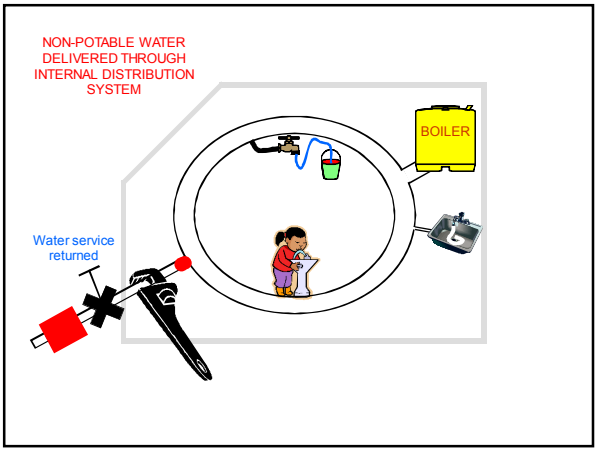


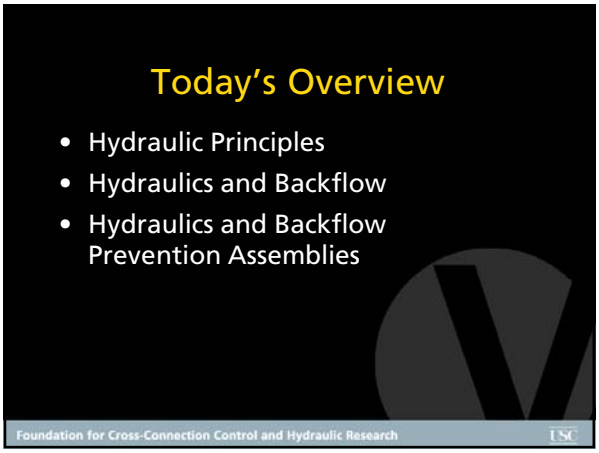





NORMAL FLOW OF POTABLE WATER THROUGH INTERNAL DISTRIBUTION SYSTEM
BOILER
Water Using Fixtures and Equipment


BACKFLOW OF NON-POTABLE WATER THROUGH INTERNAL DISTRIBUTION SYSTEM
BOILER
Water shut off for repair


NON-POTABLE WATER DELIVERED THROUGH INTERNAL DISTRIBUTION SYSTEM
BOILER
Water service returned


Today's Overview
• Hydraulic Principles
• Hydraulics and Backflow
• Hydraulics and Backflow Prevention Assemblies
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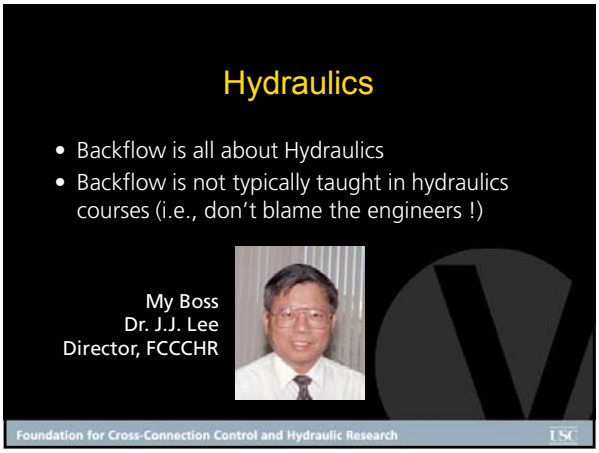
Hydraulics
• Backflow is all about Hydraulics
• Backflow is not typically taught in hydraulics courses (i.e., don't blame the engineers !)
My Boss
Dr. J.J. Lee
Director, FCCCHR
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Backflow is generally caused by a Difference in Pressure

- Backsiphonage
- Backpressure

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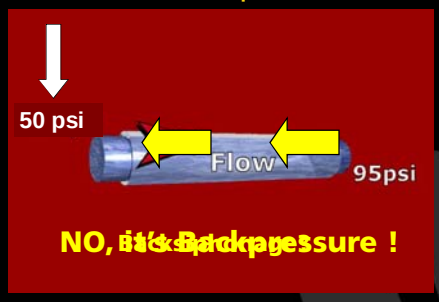
Example



NO, it's Backpressure !

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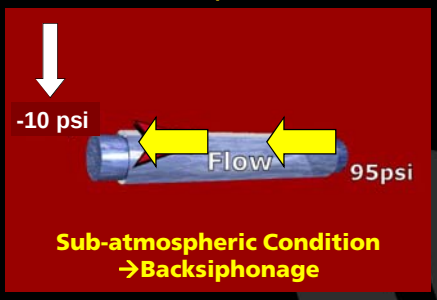
Example #2



Sub-atmospheric Condition
→Backsiphonage

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Conclusion

Water always flows from a higher pressure to a lower pressure

NO

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Common Misunderstanding

- 60-70% of Engineers taking Professional Engineering Exam miss that question
- Confirms P.E. stands for Partially Educated

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Conclusion Should Be…

Water always flows from a higher energy region to a lower energy region

Bernoulli's Equation

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Total Head: $H = \frac{V^2}{2g} + \frac{P}{\gamma} + Z + \Sigma H_L$

$\frac{V^2}{2g}$ Velocity head

$\frac{P}{\gamma}$ Pressure head

Z Elevation head

ΣH_L Sum of all head losses

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Total Head: $H = \frac{V^2}{2g} + \frac{P}{\gamma} + Z + \Sigma H_L$

When: $\frac{V^2}{2g}$ **increases**

$\frac{P}{\gamma} + Z$ **decreases**

(flowing through smaller pipe or at larger flow rate)

If Z is high enough, $\frac{P}{\gamma}$ could drop to subatmospheric

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Is It Over Yet ?

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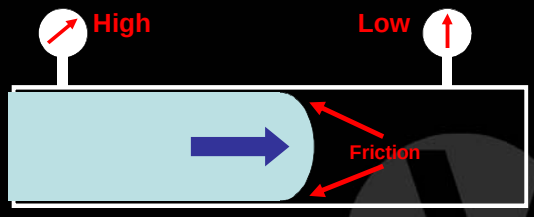
Change in Pressure



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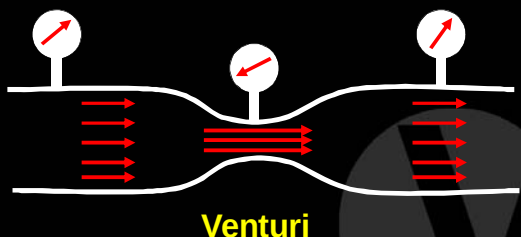
Change in Pressure



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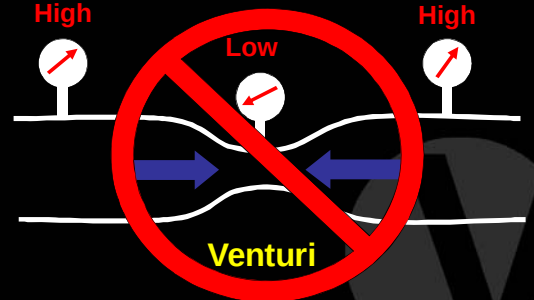
Change in Pressure



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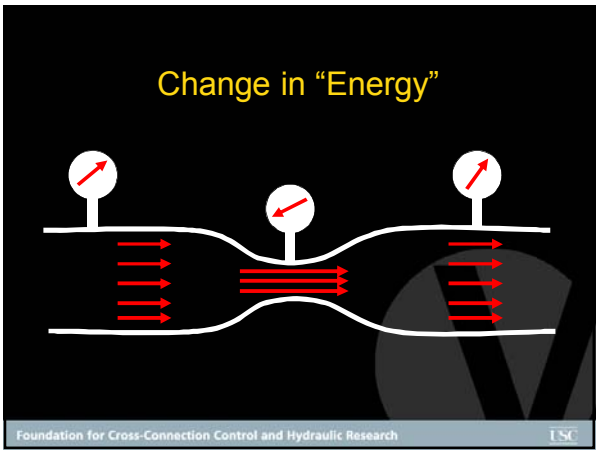
Change in "Energy"
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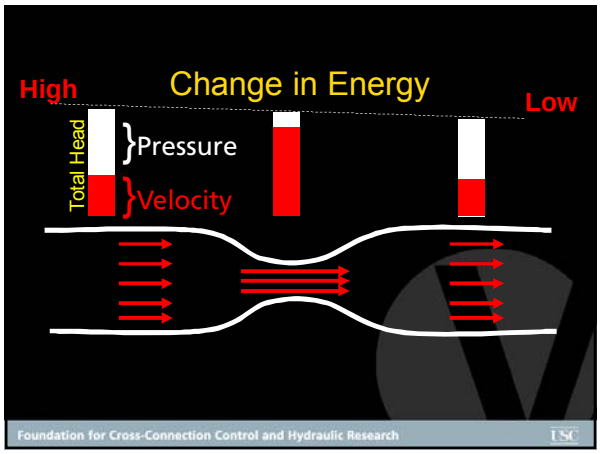
High
Change in Energy
Low
Total Head
}Pressure
}Velocity
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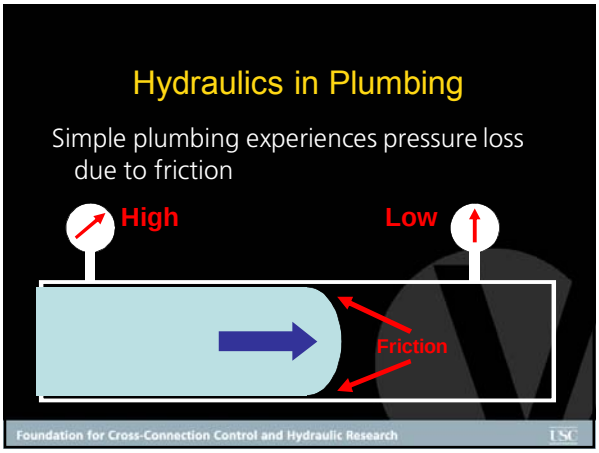
Hydraulics in Plumbing
Simple plumbing experiences pressure loss due to friction
High
Low
Friction
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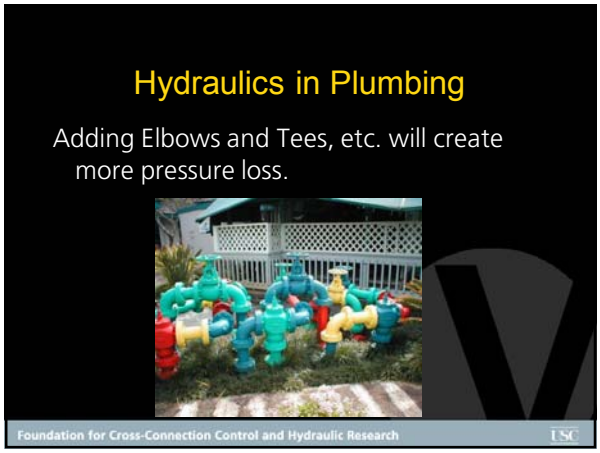
Hydraulics in Plumbing
Adding Elbows and Tees, etc. will create more pressure loss.
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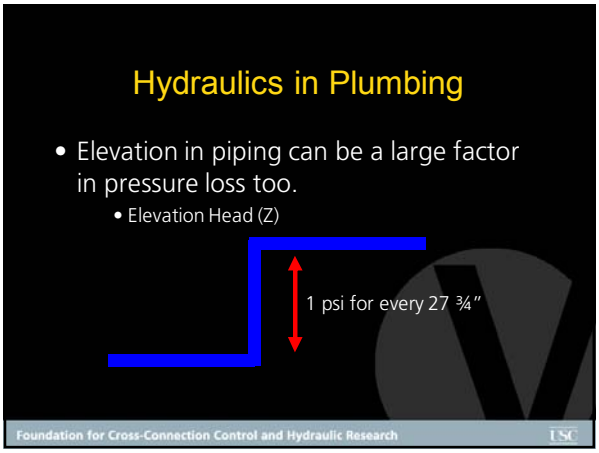
Hydraulics in Plumbing
• Elevation in piping can be a large factor in pressure loss too.
• Elevation Head (Z)
1 psi for every 27 ¾"
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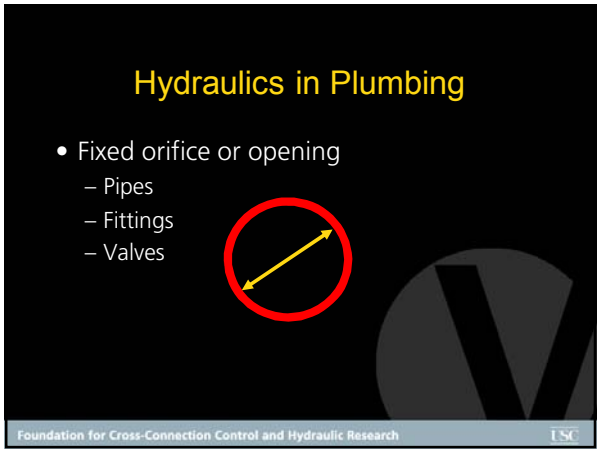
Hydraulics in Plumbing
• Fixed orifice or opening
– Pipes
– Fittings
– Valves
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Hydraulics in Plumbing

- Pressure loss can be identified by C_v
  - Valve constant
  - Characteristic of each type and size valve.

$$Q = C_v\sqrt{\Delta P}$$

1 psi

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Hydraulics in Plumbing

- Pressure loss can be identified by C_v
  - Valve constant
  - Characteristic of each type and size valve.

$$Q = C_v$$

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Hydraulics in Backflow Prevention Assemblies

- Backflow prevention assemblies don't have fixed openings/orifices
- Check valves are biased closed
  - Weight loaded
  - Spring loaded

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Hydraulics in Check Valves

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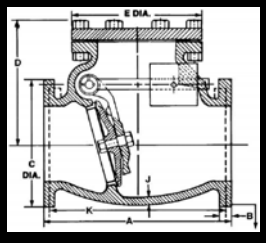
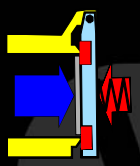
Hydraulics in Check Valves





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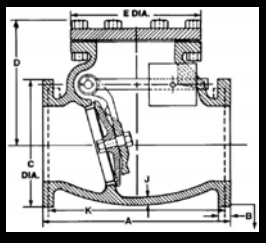
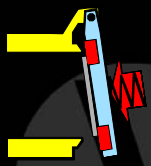
Hydraulics in Check Valves





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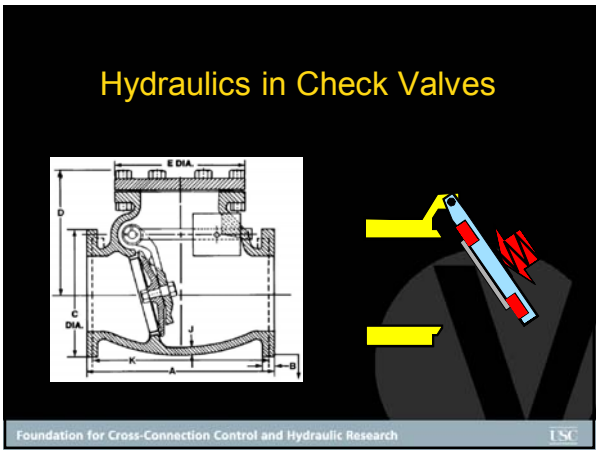
Hydraulics in Check Valves
Foundation for Cross-Connection Control and Hydraulic Research
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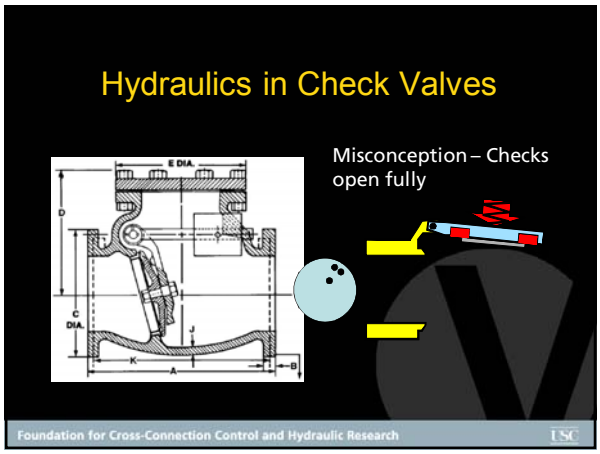
Hydraulics in Check Valves
Misconception – Checks open fully
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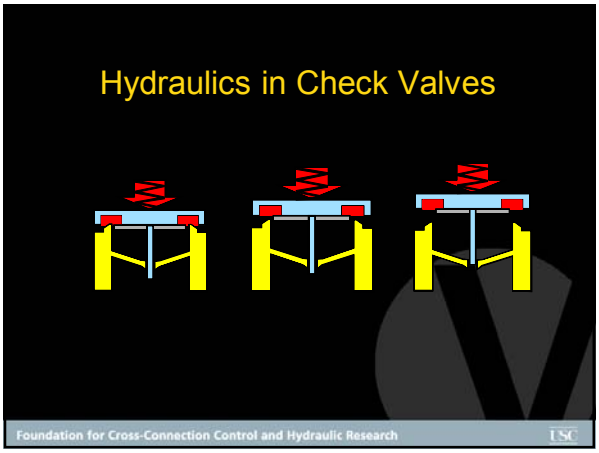
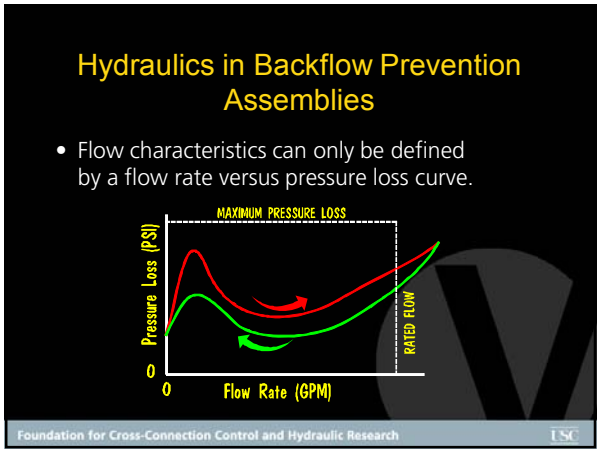
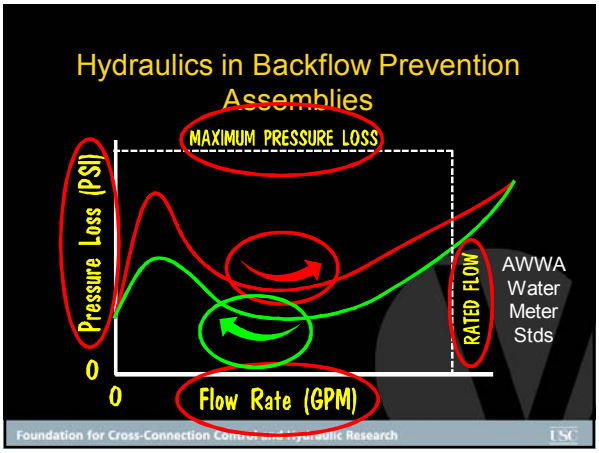
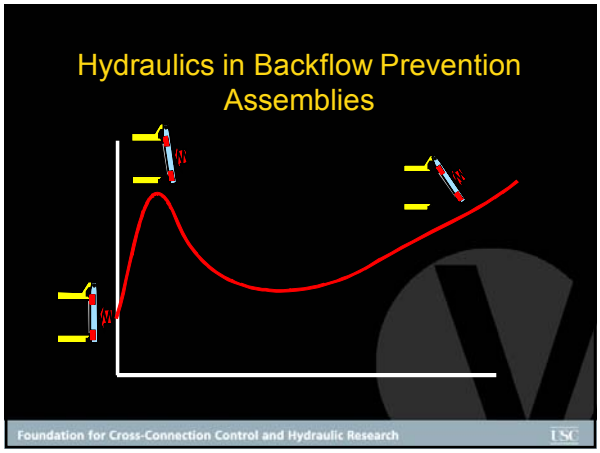

Hydraulics in Check Valves
Foundation for Cross-Connection Control and Hydraulic Research
USC


Hydraulics in Backflow Prevention Assemblies
Flow characteristics can only be defined by a flow rate versus pressure loss curve.
MAXIMUM PRESSURE LOSS
Pressure Loss (PSI)
RATED FLOW
0
0
Flow Rate (GPM)
Foundation for Cross-Connection Control and Hydraulic Research
USC


Hydraulics in Backflow Prevention Assemblies
MAXIMUM PRESSURE LOSS
Pressure Loss (PSI)
RATED FLOW
AWWA Water Meter Stds
0
0
Flow Rate (GPM)
Foundation for Cross-Connection Control and Hydraulic Research
USC


Hydraulics in Backflow Prevention Assemblies
Foundation for Cross-Connection Control and Hydraulic Research
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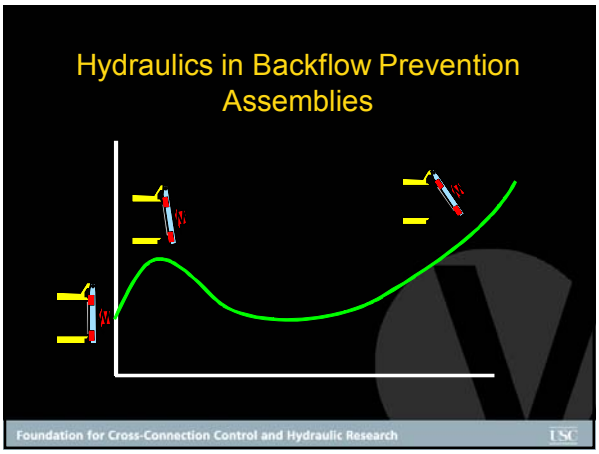
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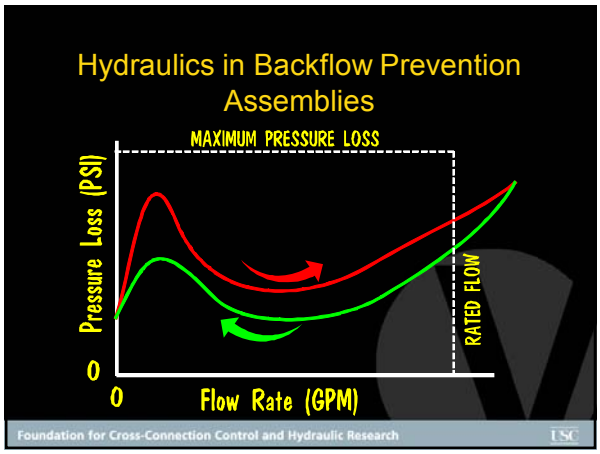
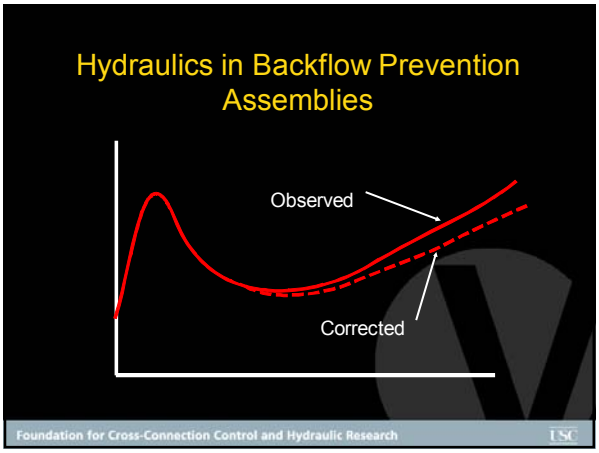

Hydraulics in Backflow Prevention Assemblies
MAXIMUM PRESSURE LOSS
Pressure Loss (PSI)
RATED FLOW
0
0
Flow Rate (GPM)
Foundation for Cross-Connection Control and Hydraulic Research
USC


Hydraulics in Backflow Prevention Assemblies
Observed
Corrected
Foundation for Cross-Connection Control and Hydraulic Research
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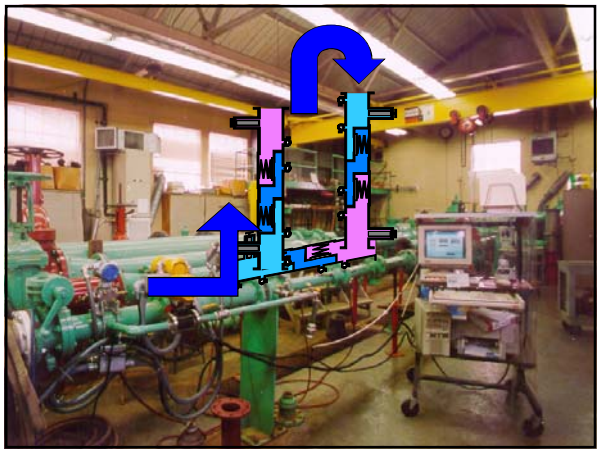

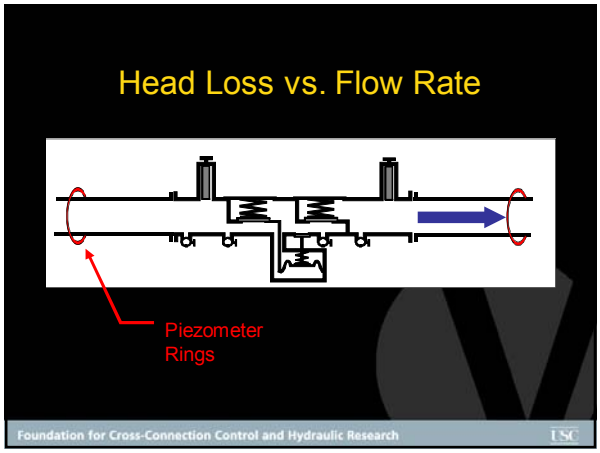
Head Loss vs. Flow Rate
Piezometer Rings
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Piezometer Ring
Foundation for Cross-Connection Control and Hydraulic Research
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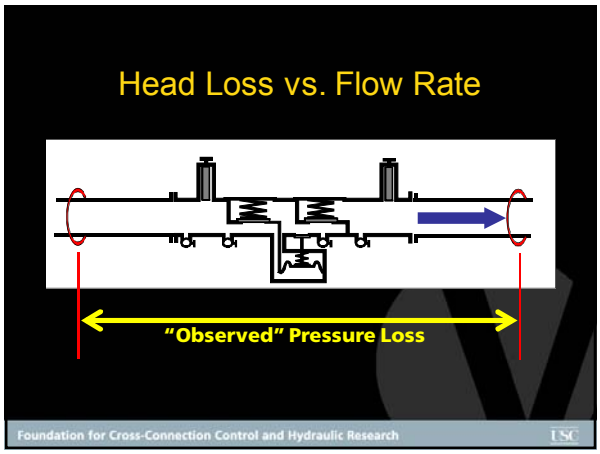
Head Loss vs. Flow Rate
"Observed" Pressure Loss
Foundation for Cross-Connection Control and Hydraulic Research
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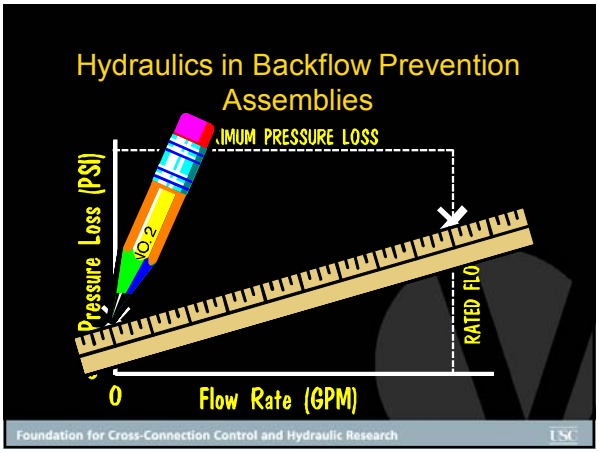
Hydraulics in Backflow Prevention Assemblies
Pressure Loss (PSI)
0
Flow Rate (GPM)
RATED FLO
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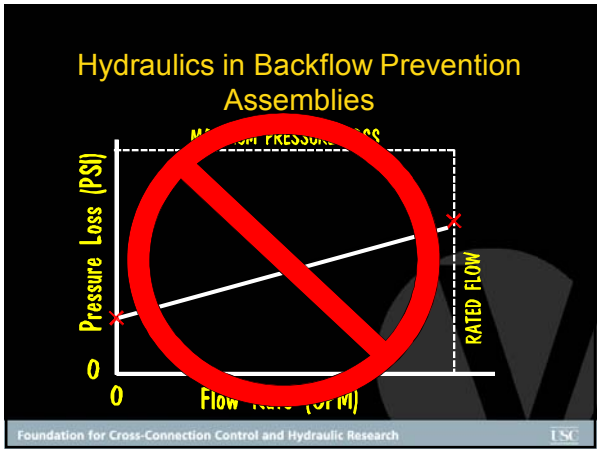
Hydraulics in Backflow Prevention Assemblies
Pressure Loss (PSI)
0
RATED FLOW
Foundation for Cross-Connection Control and Hydraulic Research
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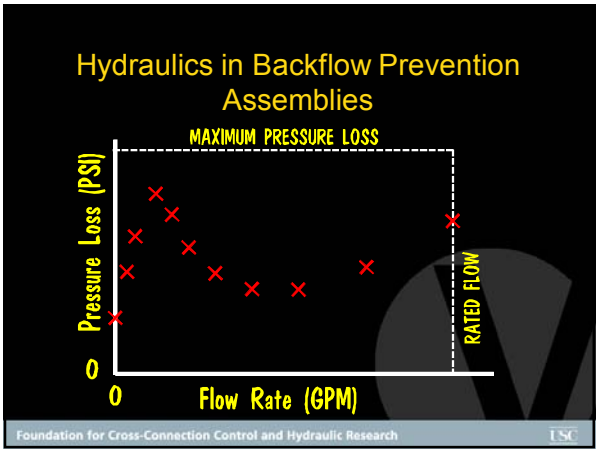
Hydraulics in Backflow Prevention Assemblies
MAXIMUM PRESSURE LOSS
Pressure Loss (PSI)
0
Flow Rate (GPM)
RATED FLOW
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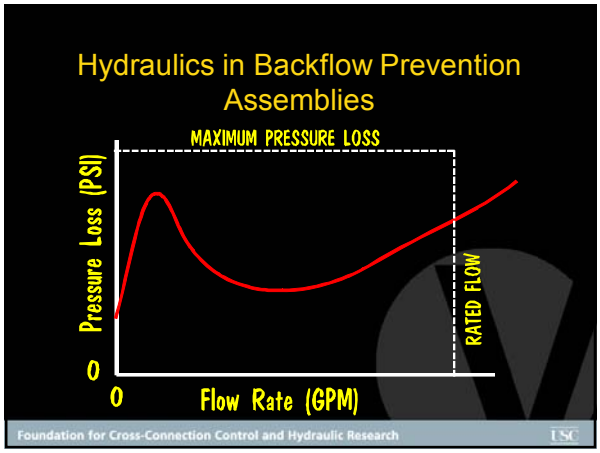
Hydraulics in Backflow Prevention Assemblies
MAXIMUM PRESSURE LOSS
Pressure Loss (PSI)
0
Flow Rate (GPM)
RATED FLOW
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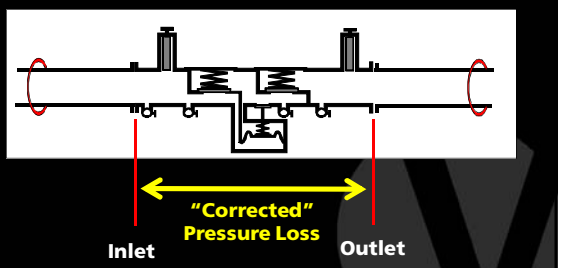
Head Loss vs. Flow Rate



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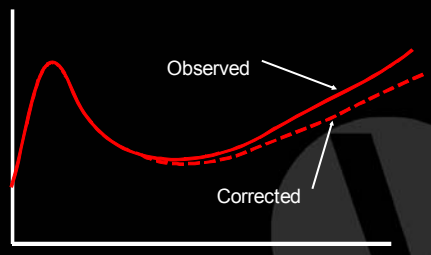
Hydraulics in Backflow Prevention Assemblies



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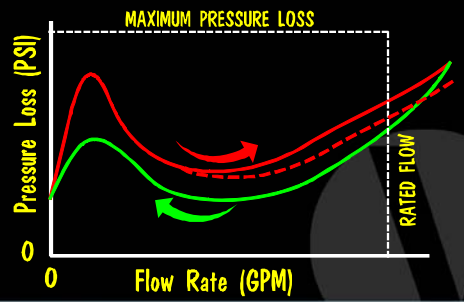
Hydraulics in Backflow Prevention Assemblies



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Over sizing of Assemblies

- Bigger means better?
- Affects operation of assembly?

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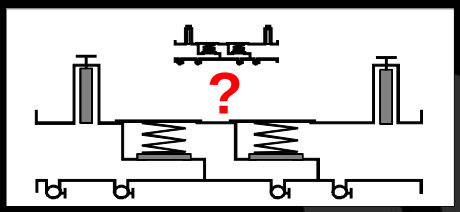
Over Sizing of assemblies



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Adequate flow and pressure?

- Oversize backflow preventer
  - Provide more water?
  - Provide more pressure?
- Compare flow curves

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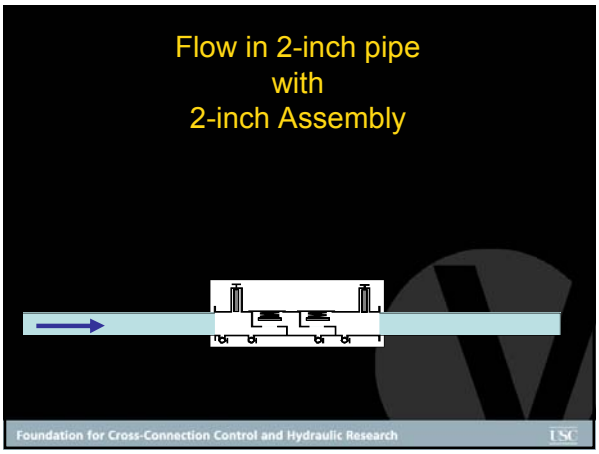
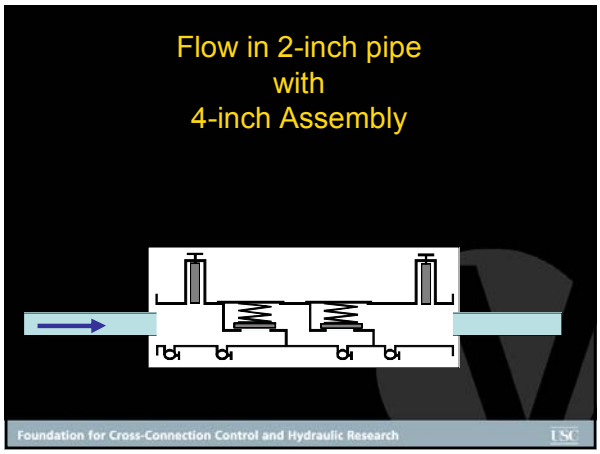

Flow in 2-inch pipe
with
2-inch Assembly
Foundation for Cross-Connection Control and Hydraulic Research
USC


Flow in 2-inch pipe
with
4-inch Assembly
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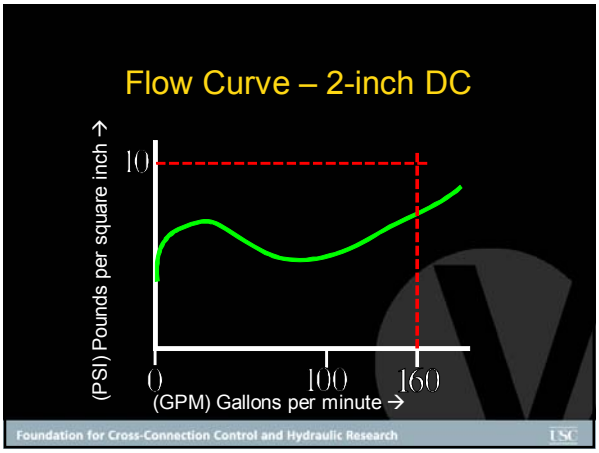
USC


Flow Curve – 2-inch DC
(PSI) Pounds per square inch →
10
0
100
160
(GPM) Gallons per minute →
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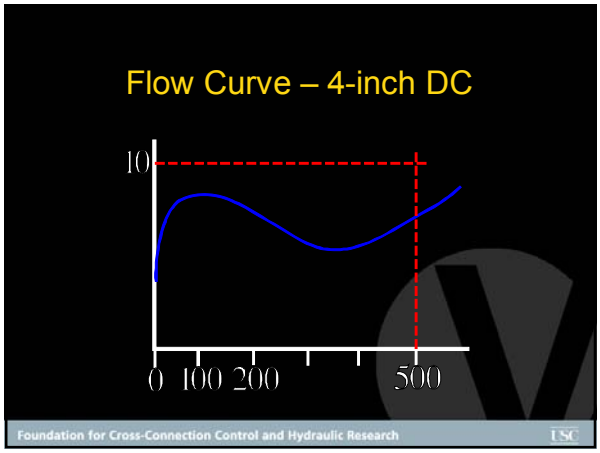
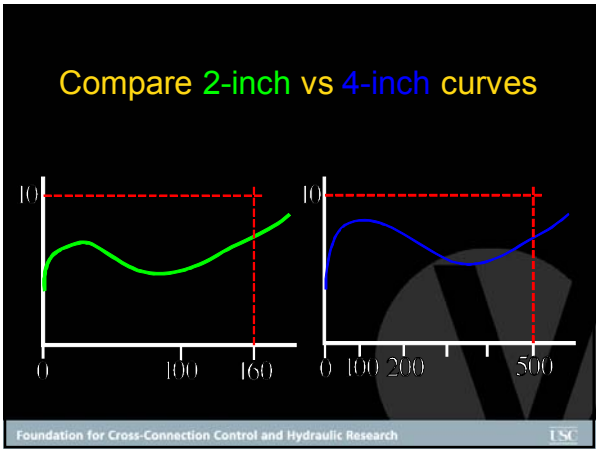
USC


Flow Curve – 4-inch DC
10
0 100 200
500
Foundation for Cross-Connection Control and Hydraulic Research
USC


Compare 2-inch vs 4-inch curves
10
0
100
160
10
0 100 200
500
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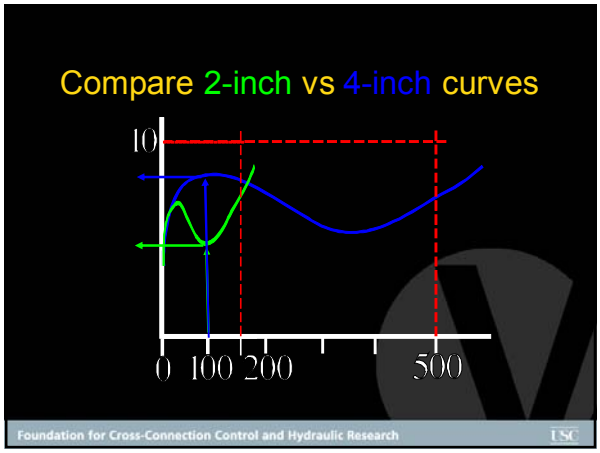
Compare 2-inch vs 4-inch curves
10
0 100 200
500
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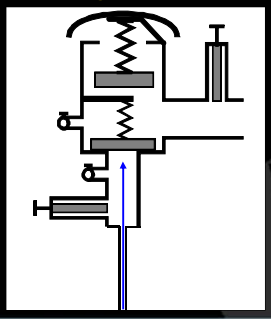
Over Sizing of Assemblies



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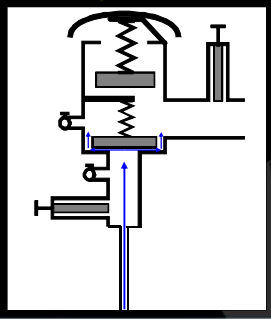
Over Sizing of Assemblies



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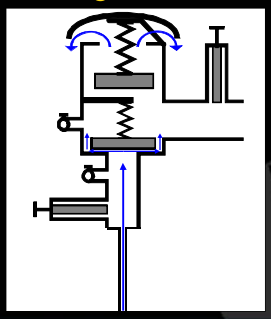
Over Sizing of Assemblies



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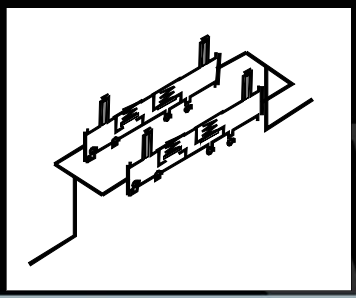
Parallel Assemblies



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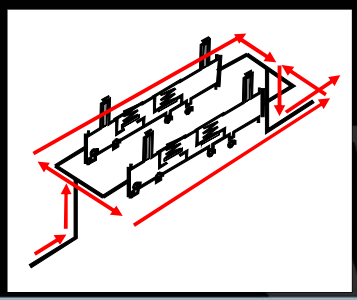
Parallel Assemblies



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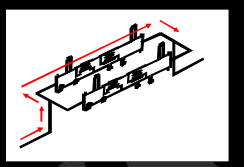
Parallel Assemblies

- Operate independently
  - Primary
  - Secondary
- Path of least resistance
  - No two assemblies are identical
- Maintenance/Repair records may differ



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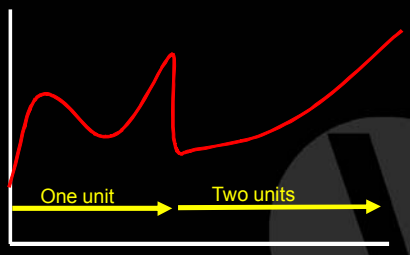
Parallel Assemblies



Foundation for Cross-Connection Control and Hydraulic Research USC

Manual - 10th Edition

- Chapter 9 - Field Test Procedures
  - Many Updates
  - Clarify diagnostics/troubleshooting
  - New procedures
    - DCDA-II
    - RPDA-II

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9th vs 10th Field Test Procedures

- Side by side comparison
- Reason for modification

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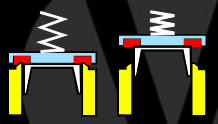
Manual - 10th Edition

- Chapter 9 - Field Test Procedures
  - Preliminary Steps
    - "Field Test Kit" vs "gage"
    - Flushing test cocks
      - Fully?
      - Foreign material
      - Verify pressure is available
    - Legend for illustrations
      - Check valves open/closed
        - » Flowing/static
      - Testcocks open/closed



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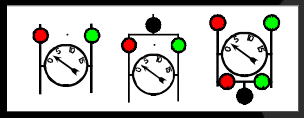
Manual - 10th Edition

- **Section 9.2** — Reduced Pressure Principle Backflow Prevention Assembly (RP)
  - 9.2.1 – Five needle valve field test kit
  - 9.2.2 - Two needle valve field test kit
  - 9.2.3 – Three needle valve field test kit



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9th vs 10th Field Test Procedures

Reduced Pressure Principle Assembly (RP)	
9th Edition	**10th Edition**
Test Cock Flushing	
Test No. 1, Step a: Open TC No. 4, open/close TC No. 1, open/close TC No. 2, open/close TC No. 3, and close TC No. 4	***Test No. 1, Step a:*** Open TC No. 4, open TC No. 3, open TC No. 2, open TC No. 1; then close TC No. 1, close TC No. 2, close TC No. 3, and close TC No. 4
REASON: *This is to ensure that there is flow through the assembly to minimize the possibility of discharging the relief valve, especially if under a backpressure condition.*	

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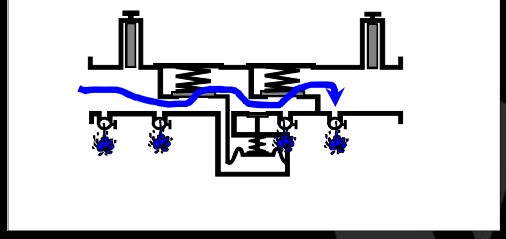
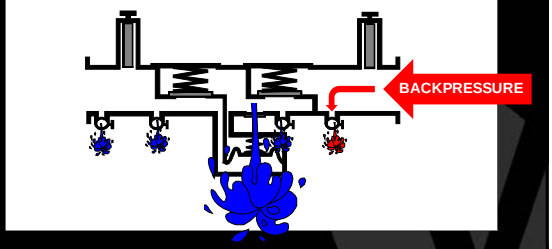
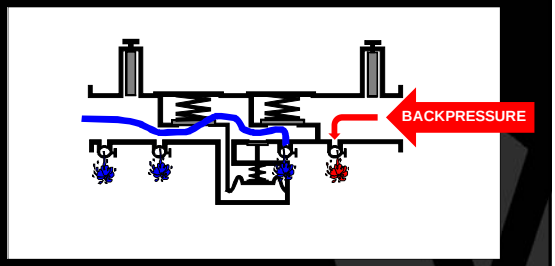
RP - Test Cock Flushing – 9th



RP - Test Cock Flushing – 9th



RP - Test Cock Flushing – 10th



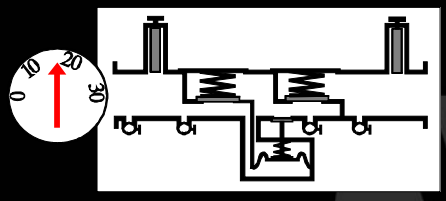
9th vs 10th Field Test Procedures

Reduced Pressure Principle Assembly (RP)	
9th Edition	**10th Edition**
Check Valve No. 1	
Test No. 3, Step a: First check valve reading should be 3.0 psid greater than the relief valve opening point.	***Test No. 3, Step a: First check valve reading*** must be above the relief valve opening point and ≥ 5.0 psid
REASON: *To provide a required minimum value for the first check valve*	

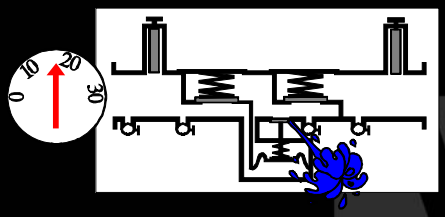
9th vs 10th Field Test Procedures

Reduced Pressure Principle Assembly (RP)	
9th Edition	**10th Edition**
Check Valve No. 1	
Test No. 3, Step a: First check valve reading should be 3.0 psid greater than the relief valve opening point.	***Test No. 3, Step a: First check valve reading*** must be above the relief valve opening point and ≥ 5.0 psid
REASON: *To provide a required minimum value for the first check valve*	

Small Fluctuation of Pressure



Large Fluctuation of Pressure



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Manual - 10th Edition

- Chapter 9 - RP Field Test Procedures
  - 1st Check Valve
    - Eliminate recommendation for 3.0 PSID Buffer
    - Establish Minimum 5.0 PSID
      - **NOT A 5 PSI BUFFER!!!**
- Chapter 10 – RP Standard
  - 3.0 PSID buffer required during Laboratory Evaluation

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RP – 1st Check Valve Reading

Results	9th Edition	10th Edition
1st Ck: 4.5 RV: 2.0 2nd Ck: ok	PASS	FAIL
1st Ck: 5.2 RV: 4.4 2nd Ck: ok	PASS	PASS

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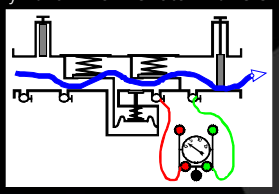
Manual - 10th Edition

- Section 9 - RP Field Test Procedures
  - 2nd Check Valve Direction of Flow
    - Only Valid if No. 2 Shutoff Valve is Tight



Info in Appendix A

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Hydraulics

- Backflow and Backflow Prevention are all about Hydraulics
- Much more info can be covered
- Presentations
  - Size-up your audience appropriately
  - Don't assume they understand even the basic hydraulic issues about backflow

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QUESTIONS

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