The Little Red Schoolhouse

Large Chilled Water System Design Seminar

Courtesy of Oslin Nation Company

Distribution Piping Strategies

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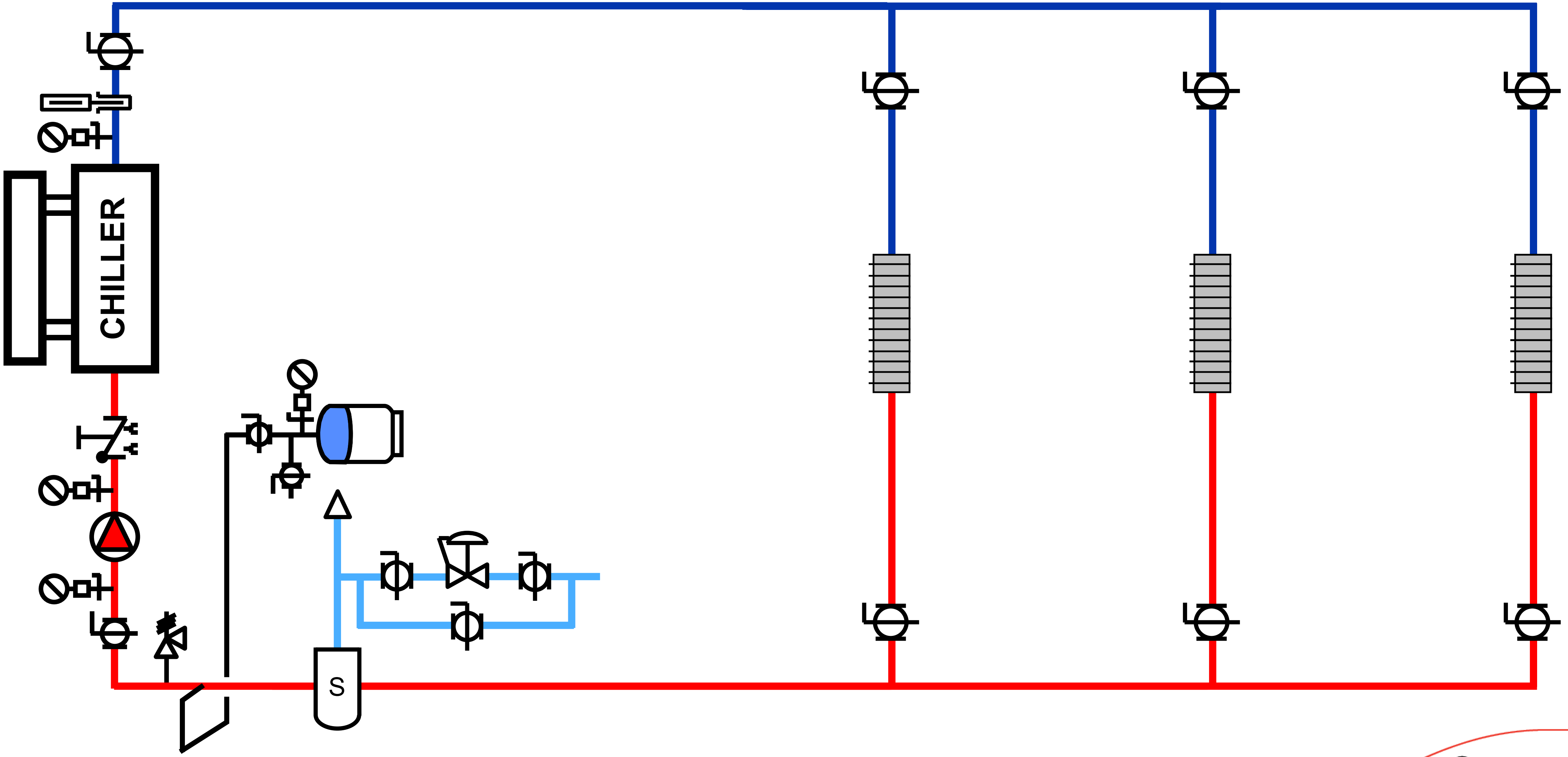
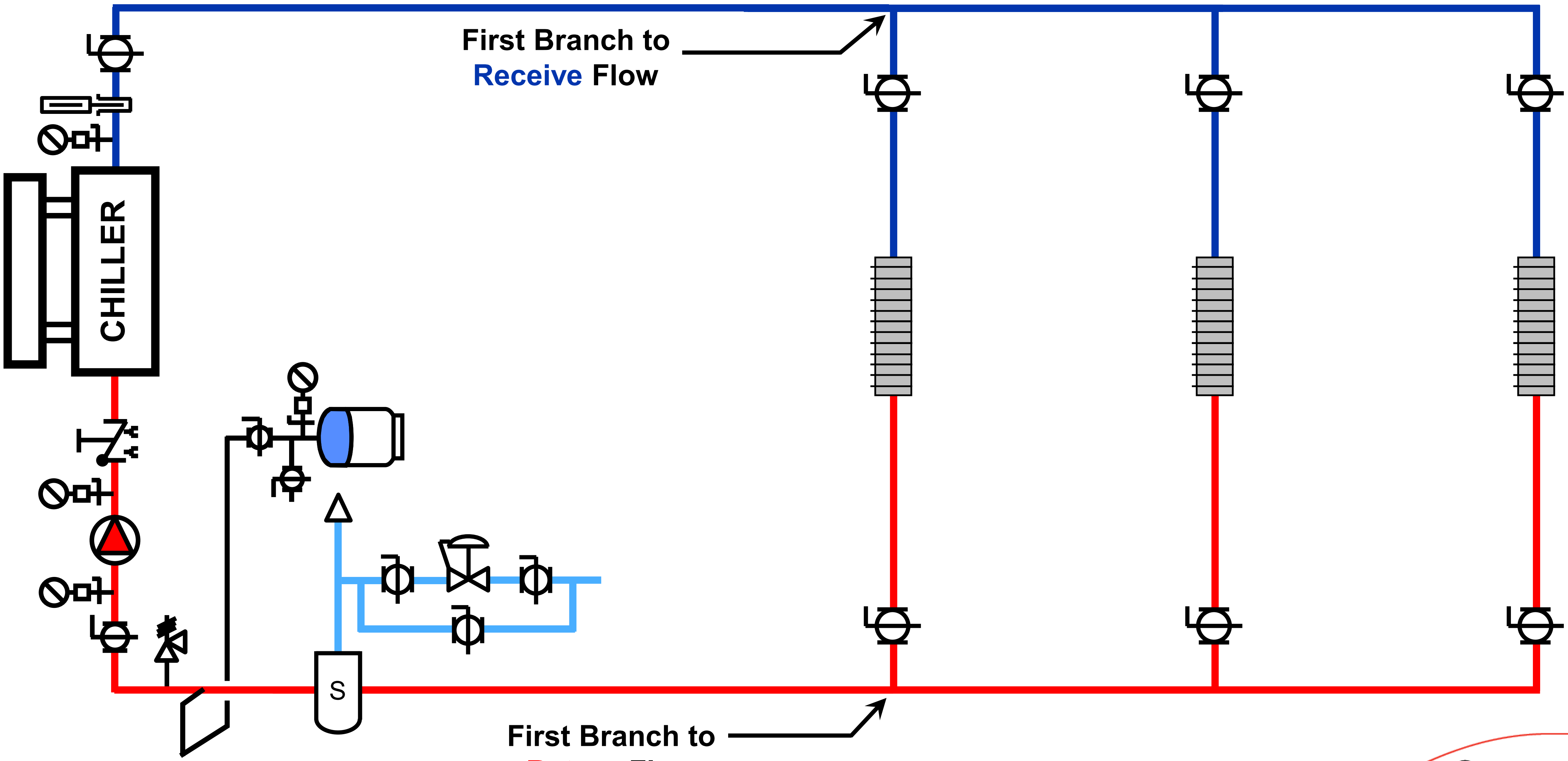
2-Pipe Parallel Circuits


CHILLER
S



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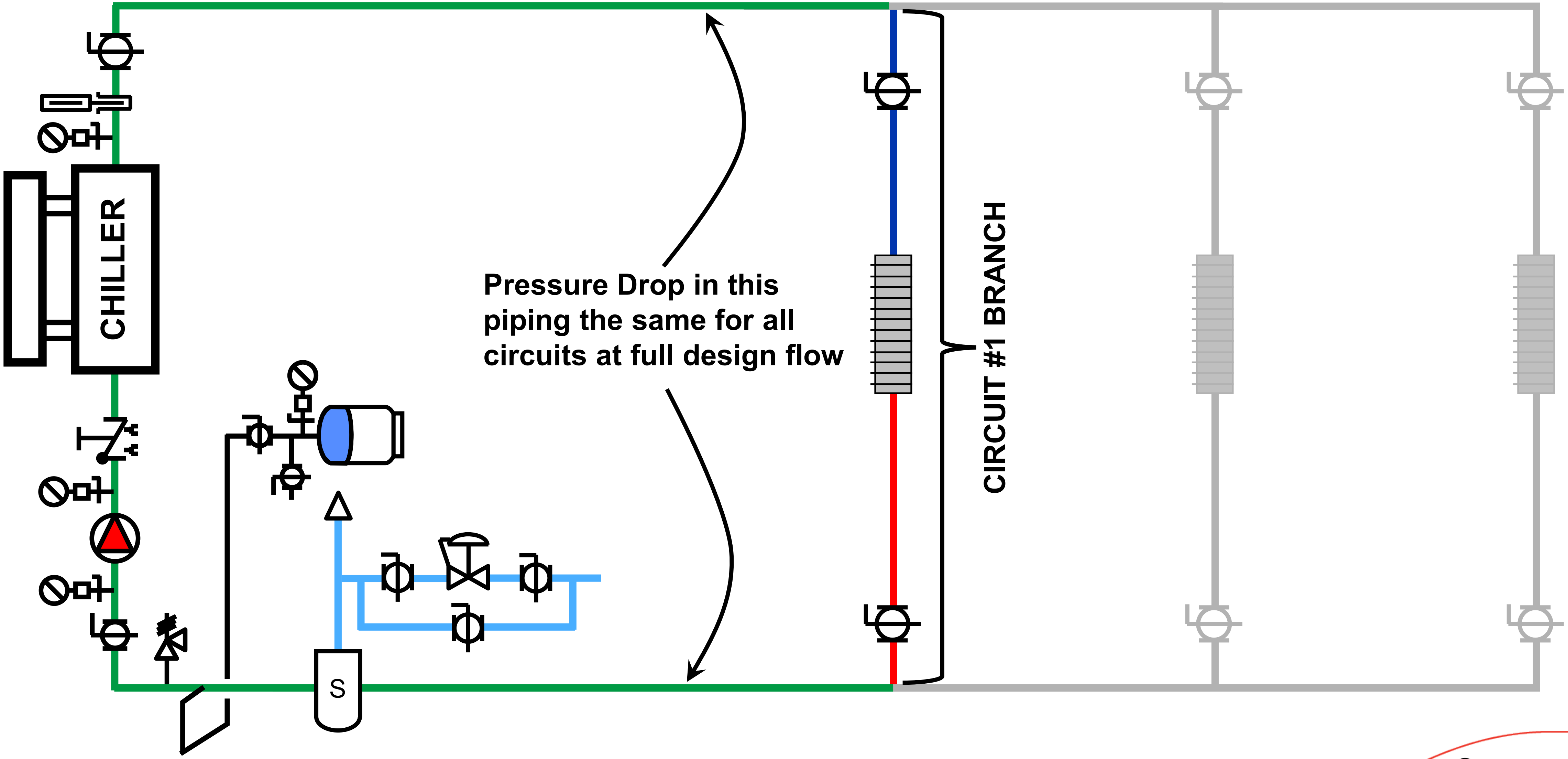
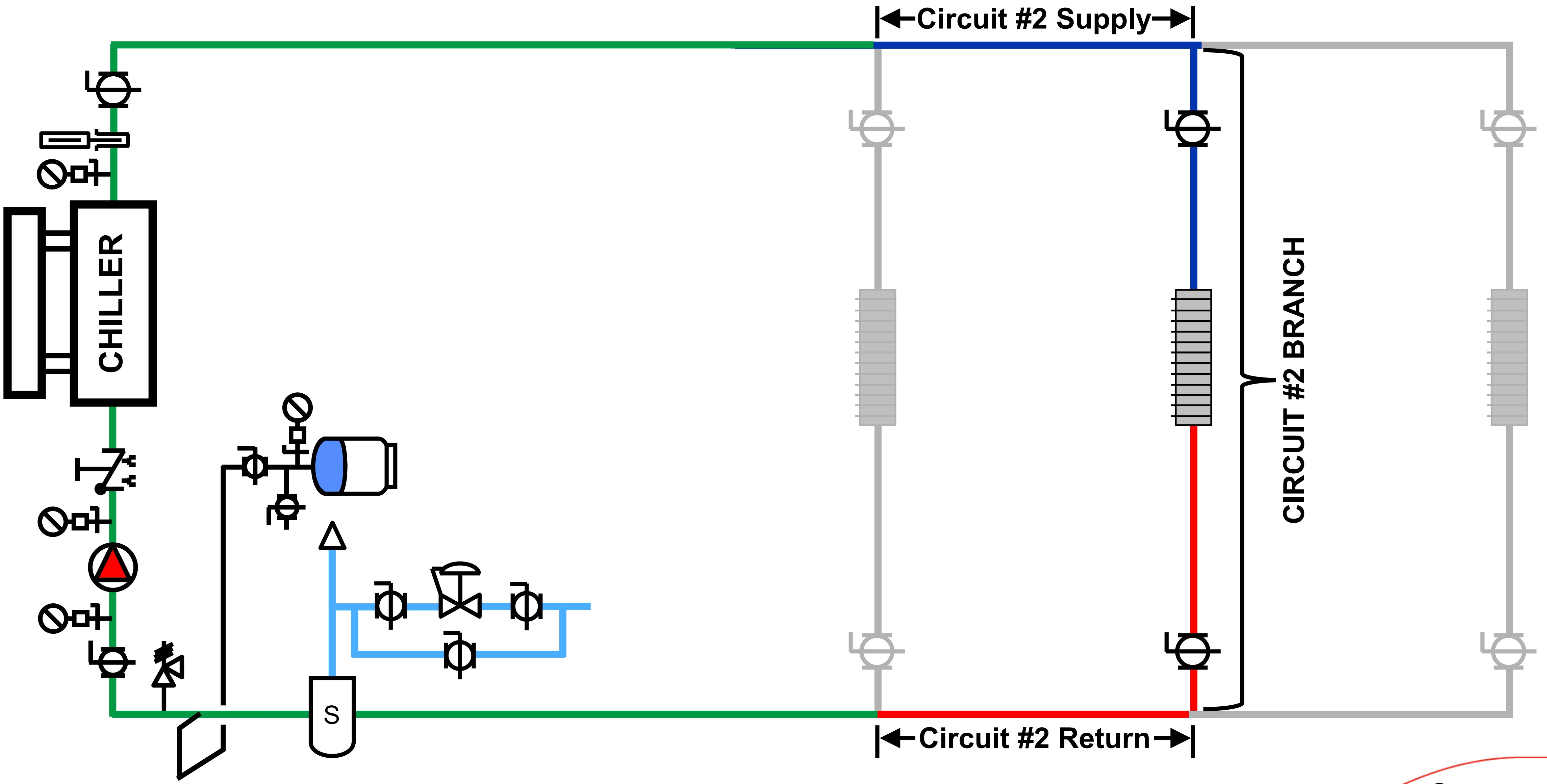
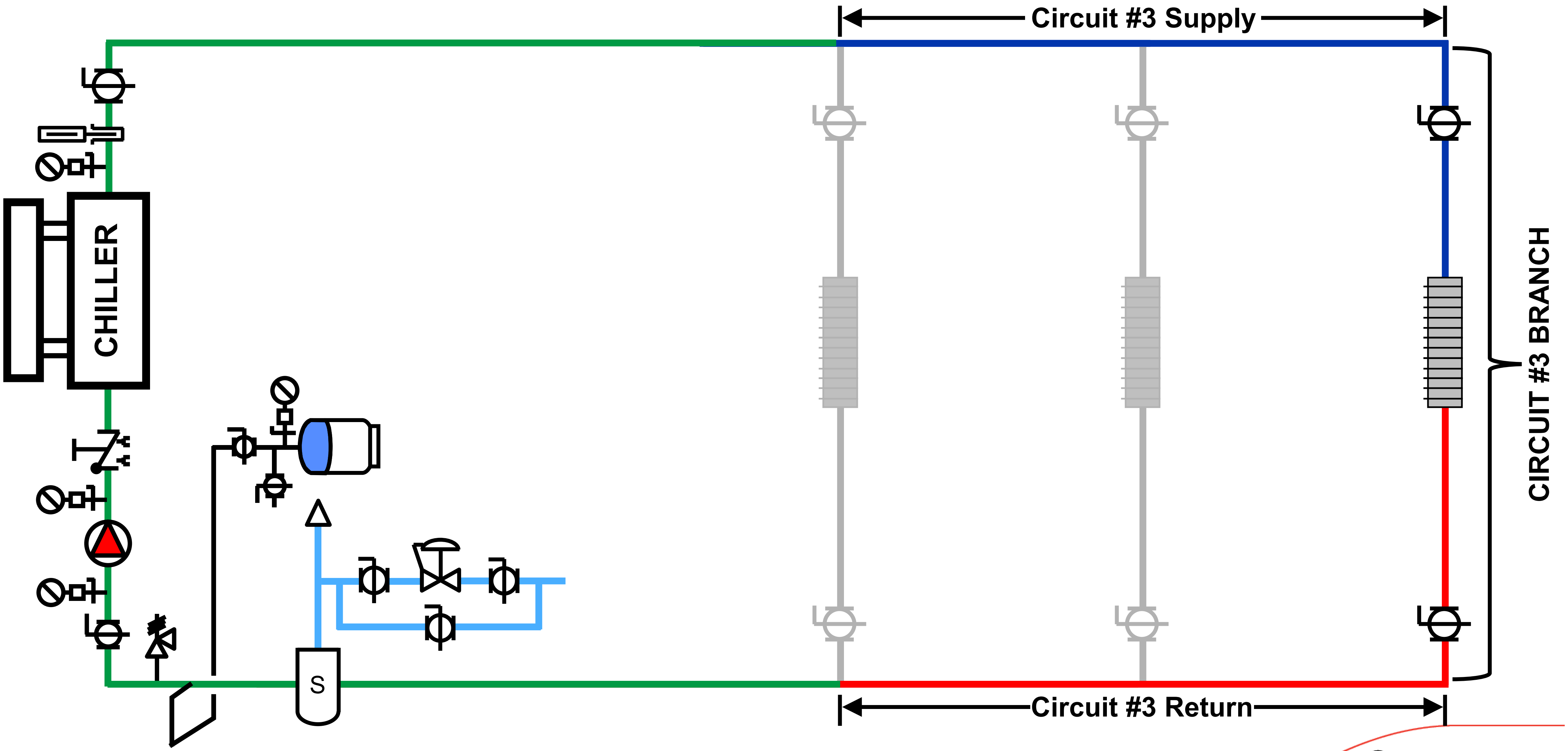
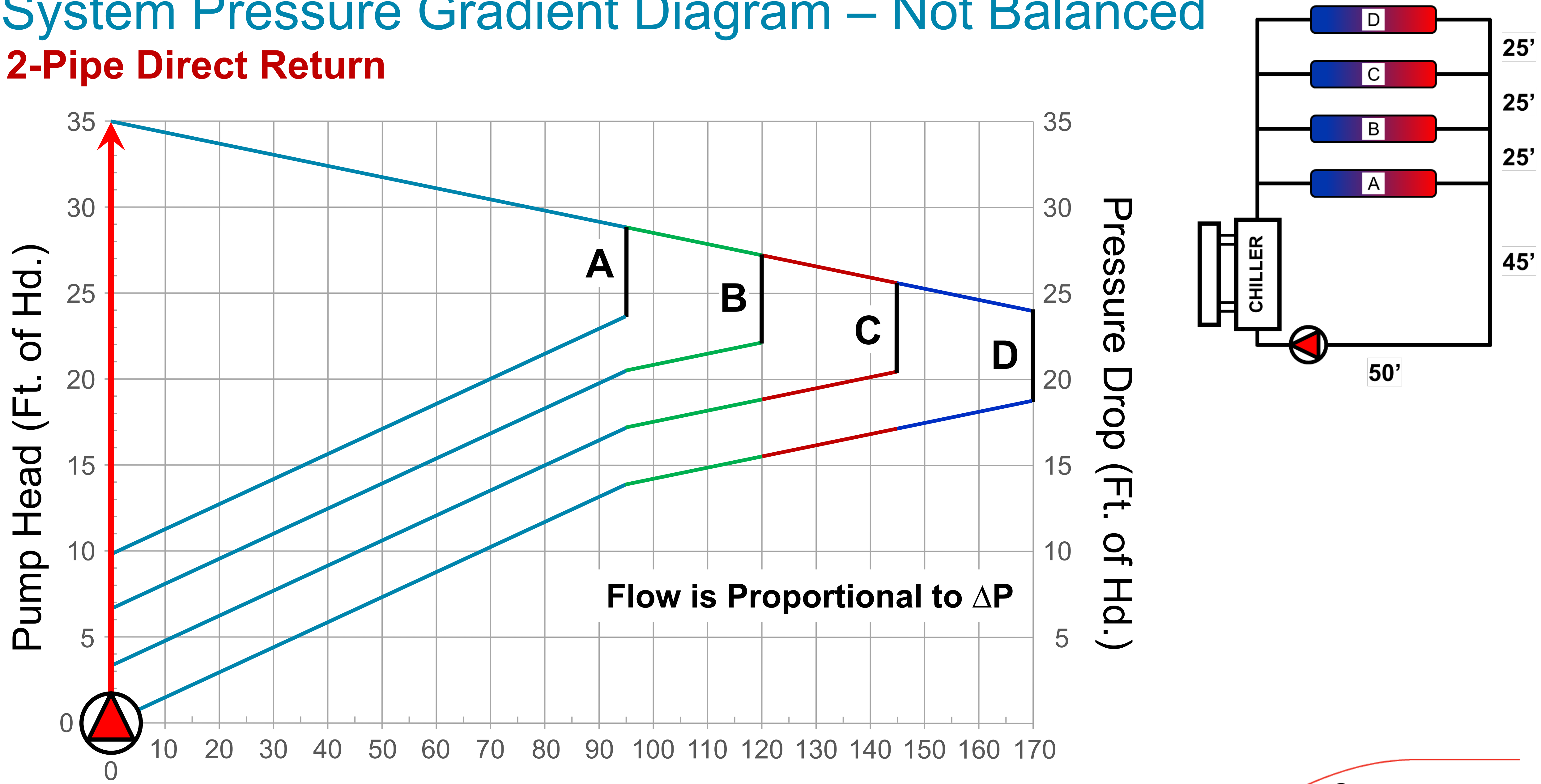

CHILLER
S
Pressure Drop in this piping the same for all circuits at full design flow
CIRCUIT #1 BRANCH


Circuit #2 Supply
CHILLER
S
CIRCUIT #2 BRANCH
Circuit #2 Return

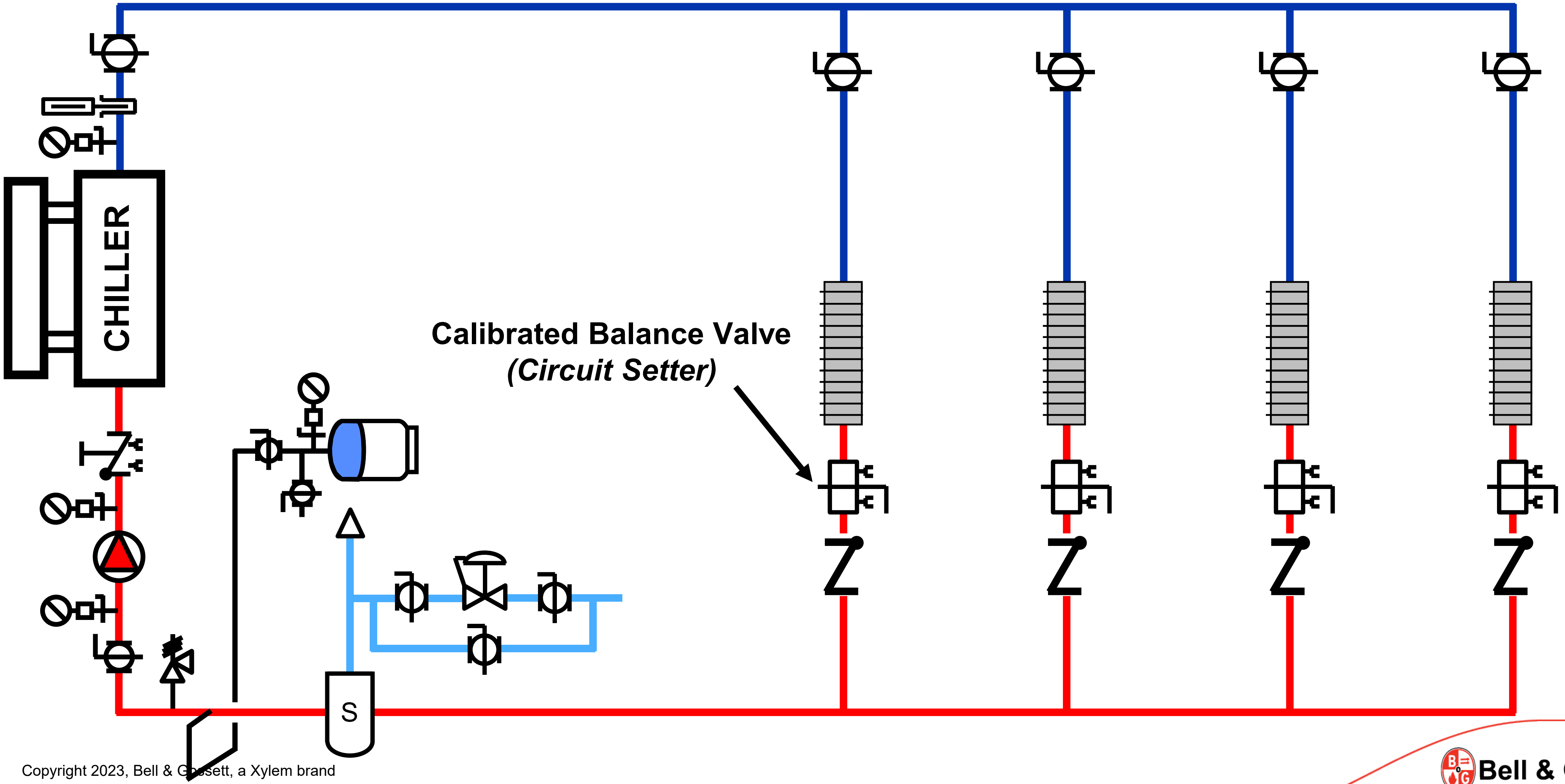

Circuit #3 Supply
CHILLER
S
CIRCUIT #3 BRANCH
Circuit #3 Return

System Pressure Gradient Diagram – Not Balanced

2-Pipe Direct Return

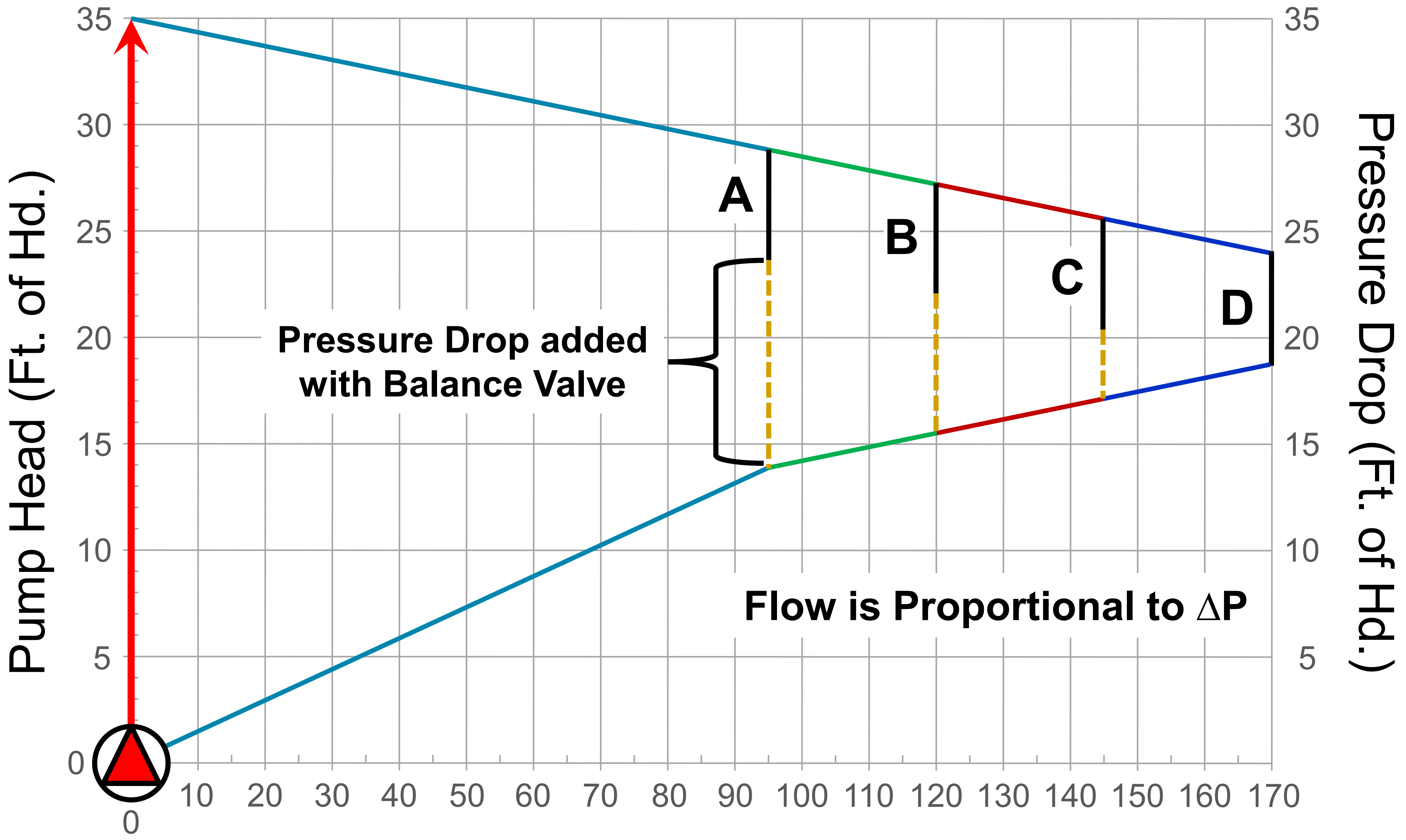


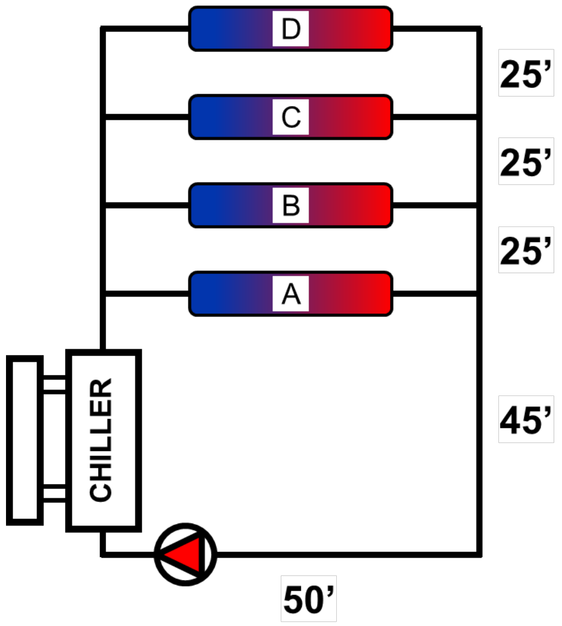
2-Pipe Parallel Circuits – **Direct Return** Flow Distribution



System Pressure Gradient Diagram – Balanced

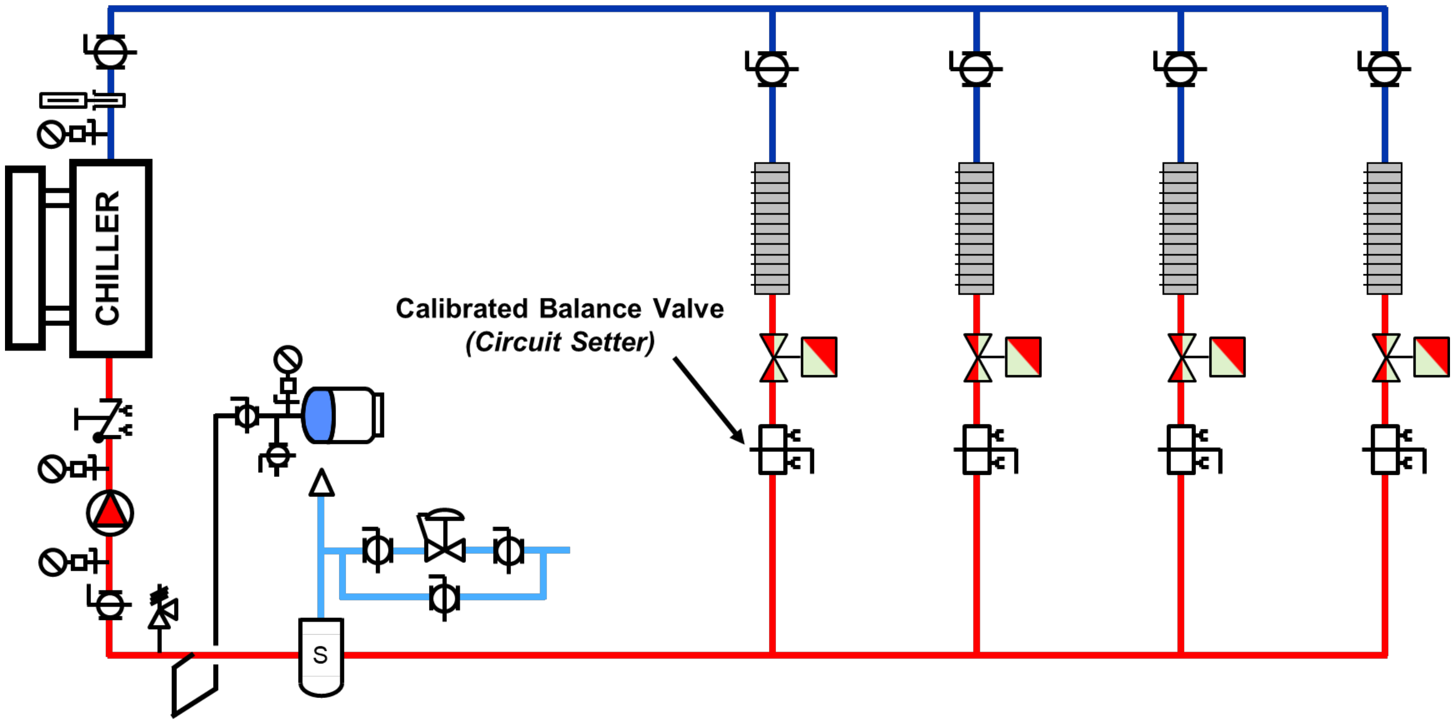
2-Pipe Direct Return



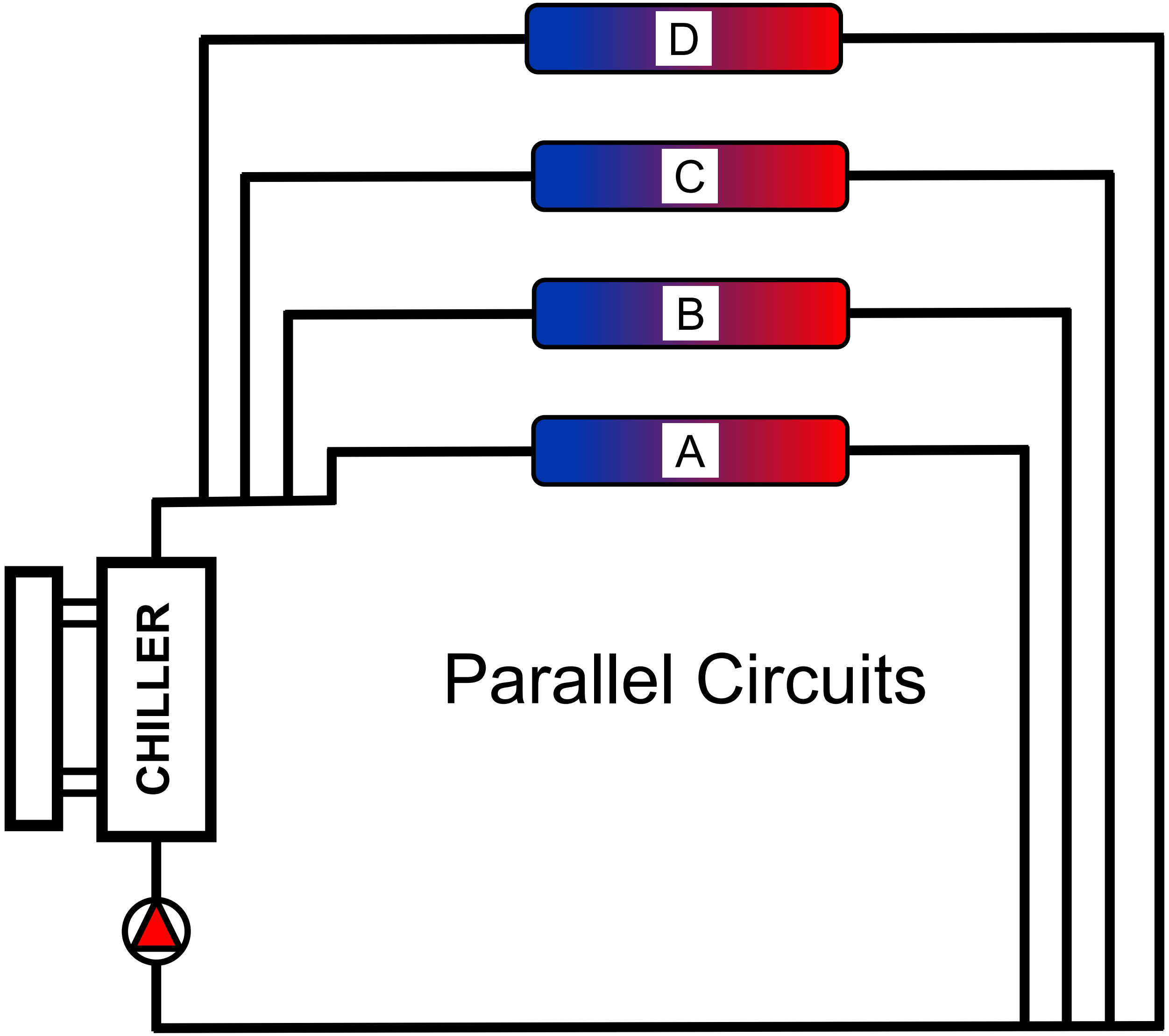


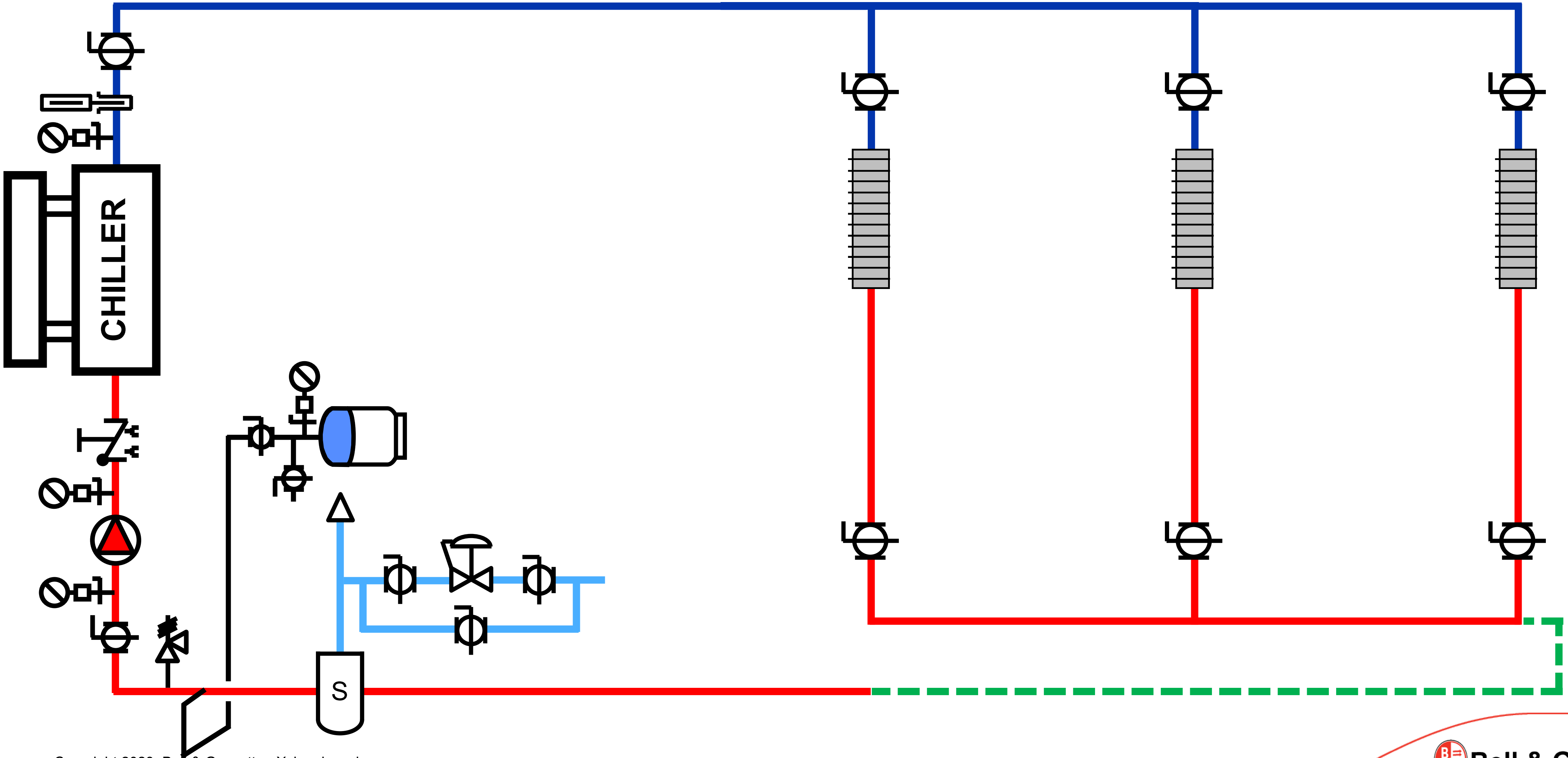
REMINDER: System Head Loss for Closed Loop Pump Sizing

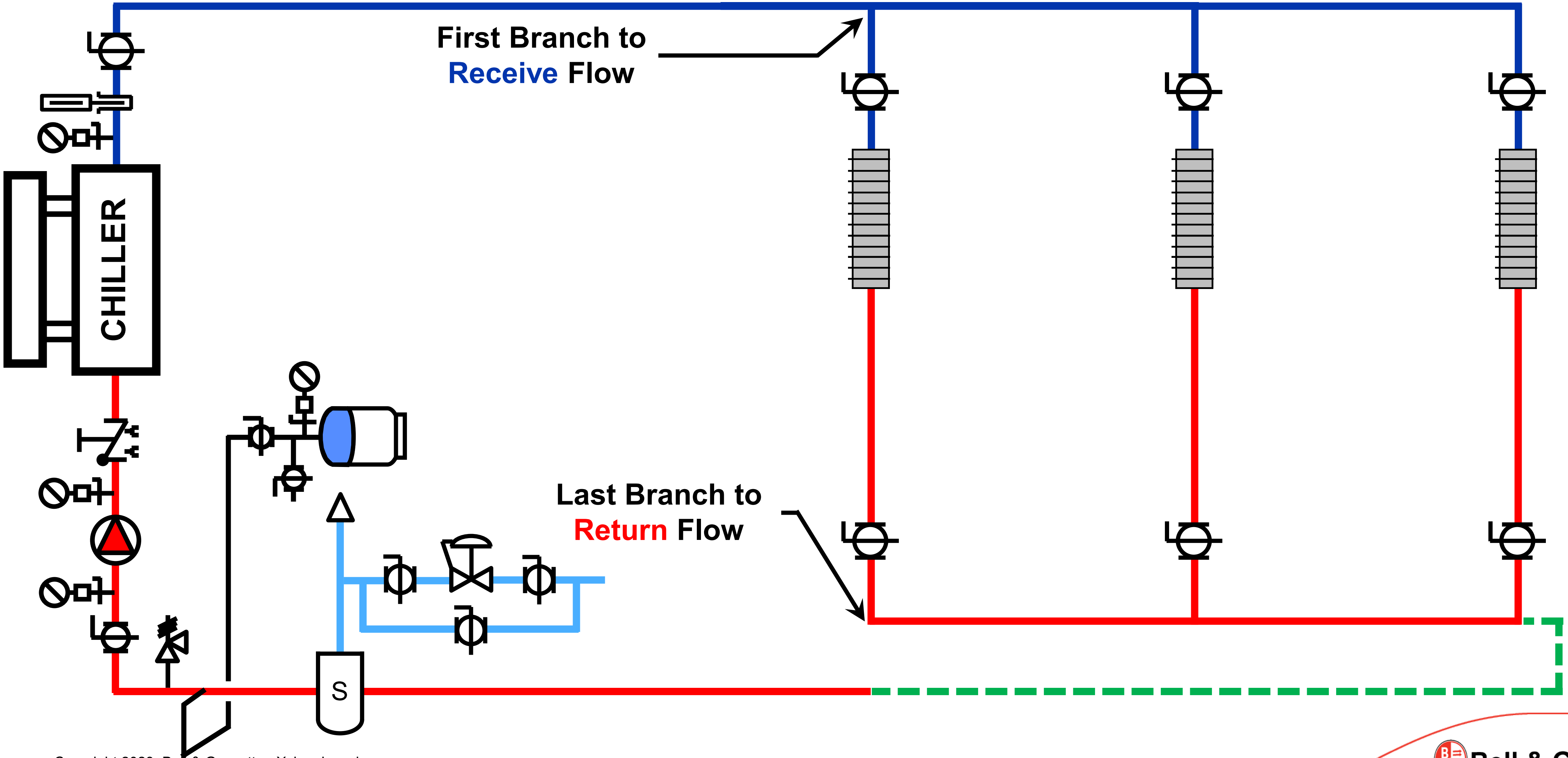
Parallel Loops



Total System Head Loss = B+C for ***Critical Circuit***


D
C
B
A
CHILLER
Parallel Circuits


CHILLER
S



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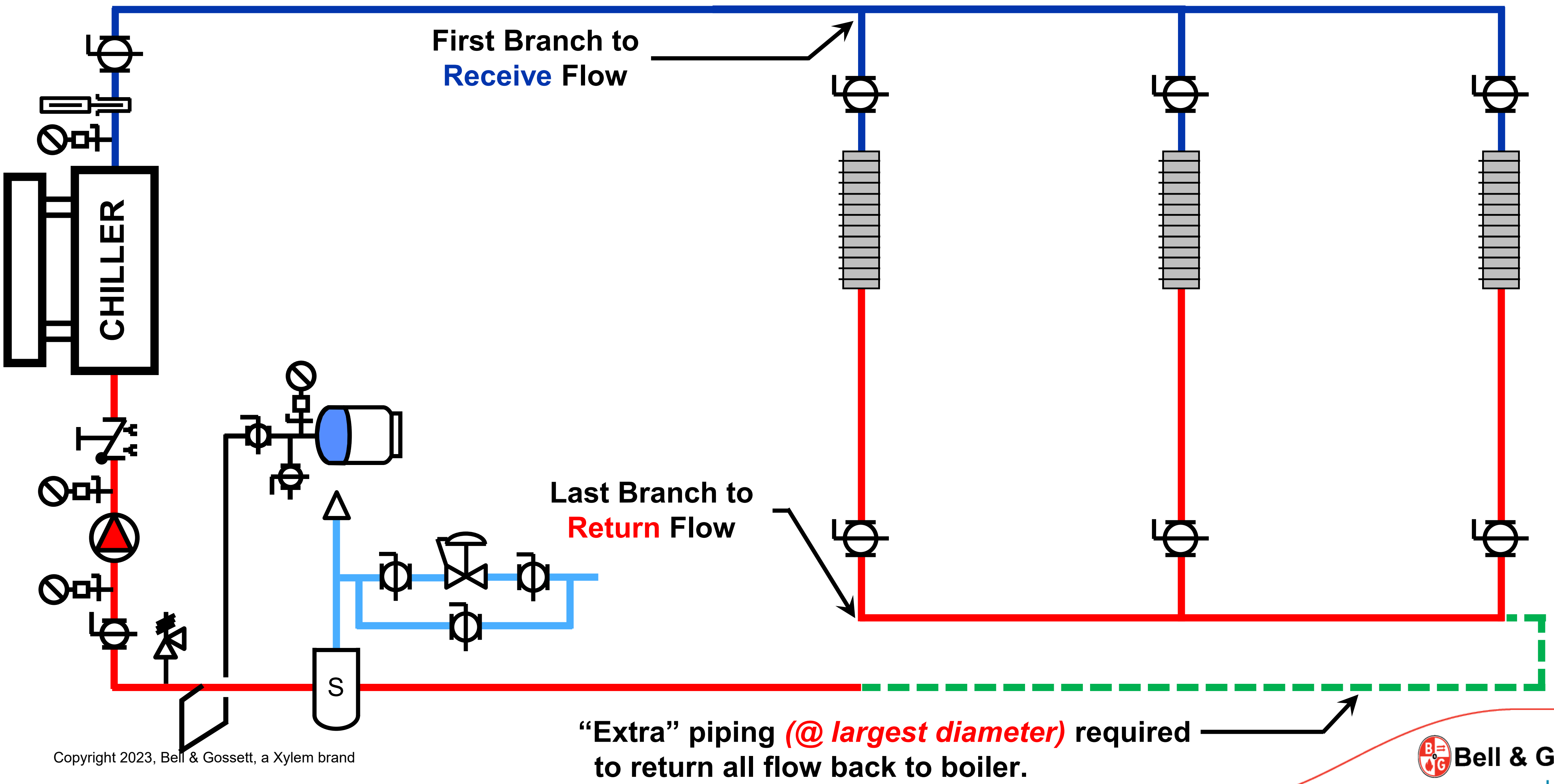
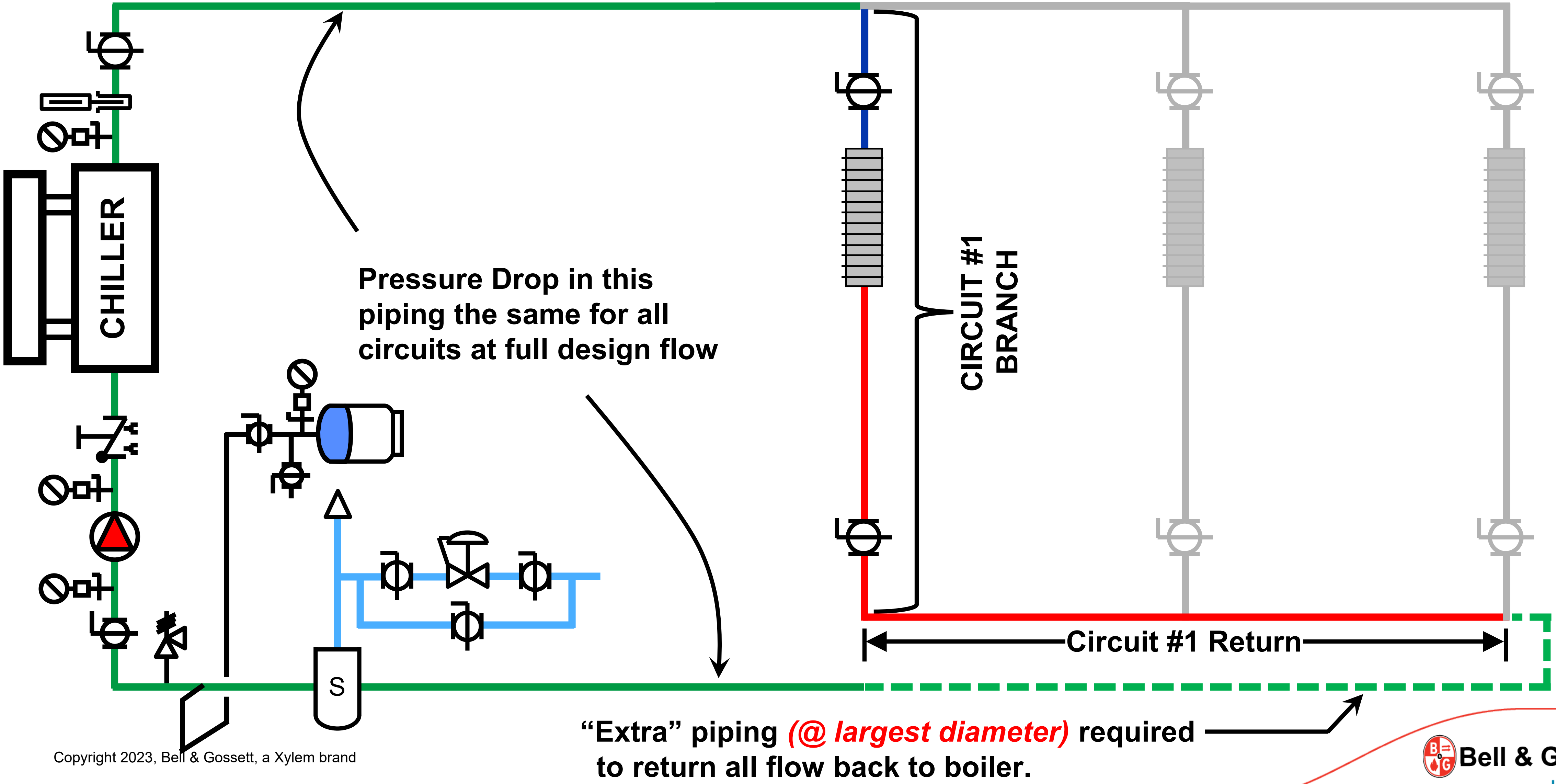

CHILLER
First Branch to
Receive Flow
Last Branch to
Return Flow
S
“Extra” piping (@ largest diameter) required
to return all flow back to boiler.



Bell & Gossett
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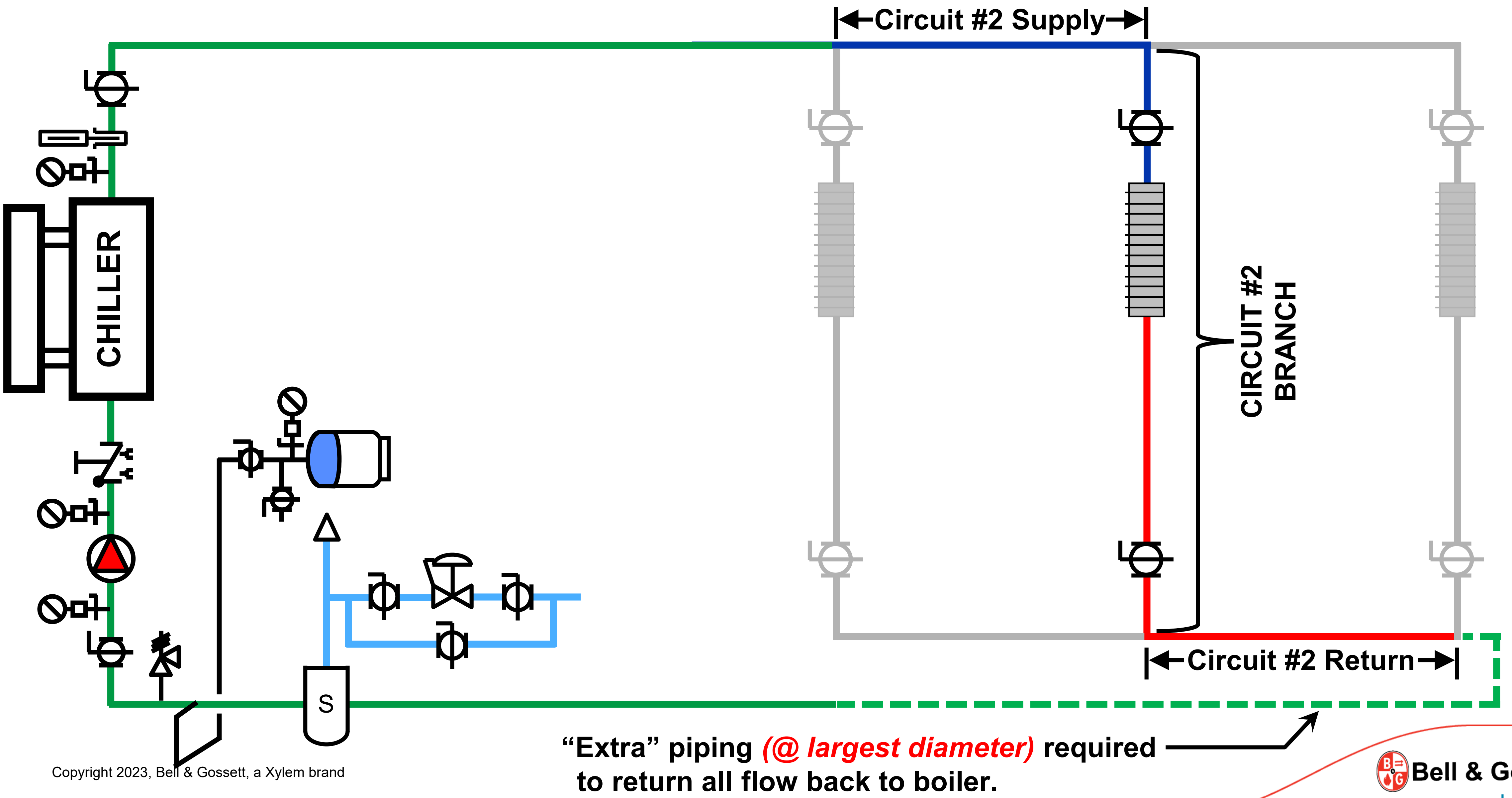
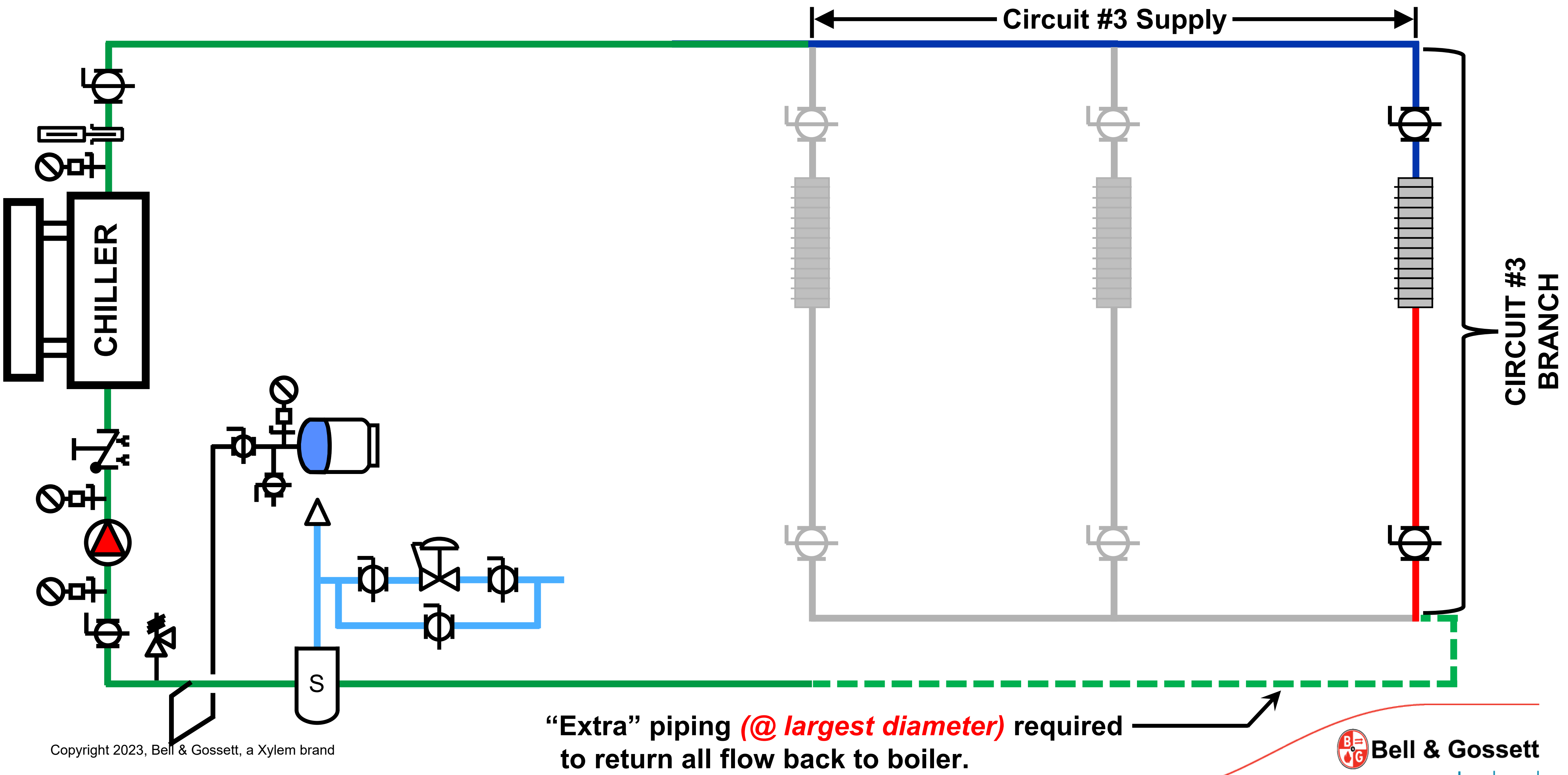
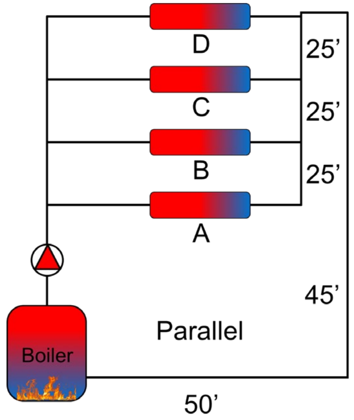

Circuit #2 Supply
CHILLER
CIRCUIT #2 BRANCH
S
Circuit #2 Return
"Extra" piping (@ largest diameter) required to return all flow back to boiler.

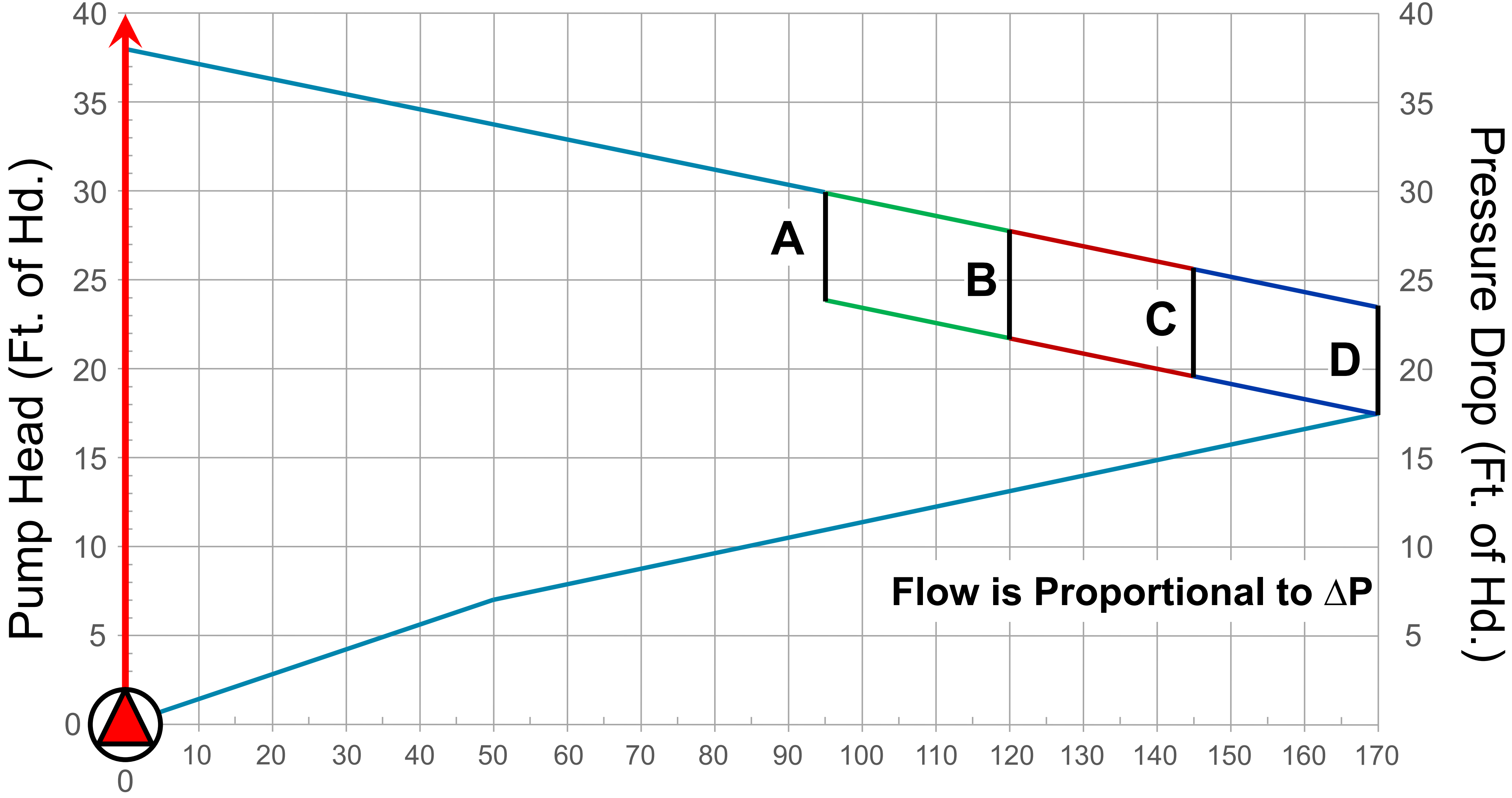


Circuit #3 Supply
CHILLER
S
CIRCUIT #3 BRANCH
"Extra" piping *(@ largest diameter)* required to return all flow back to boiler.

System Pressure Gradient Diagram – Balanced??

2-Pipe Reverse Return





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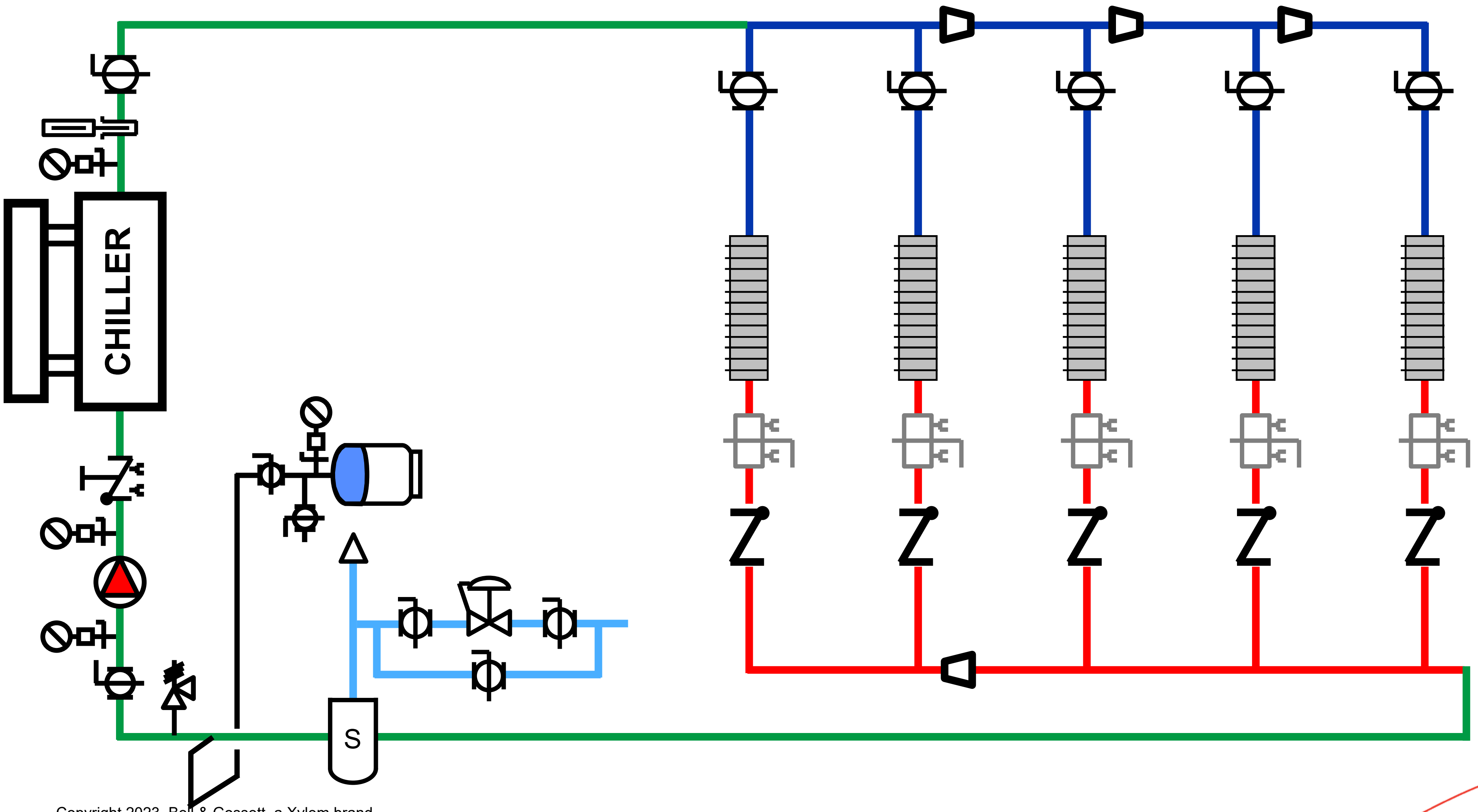
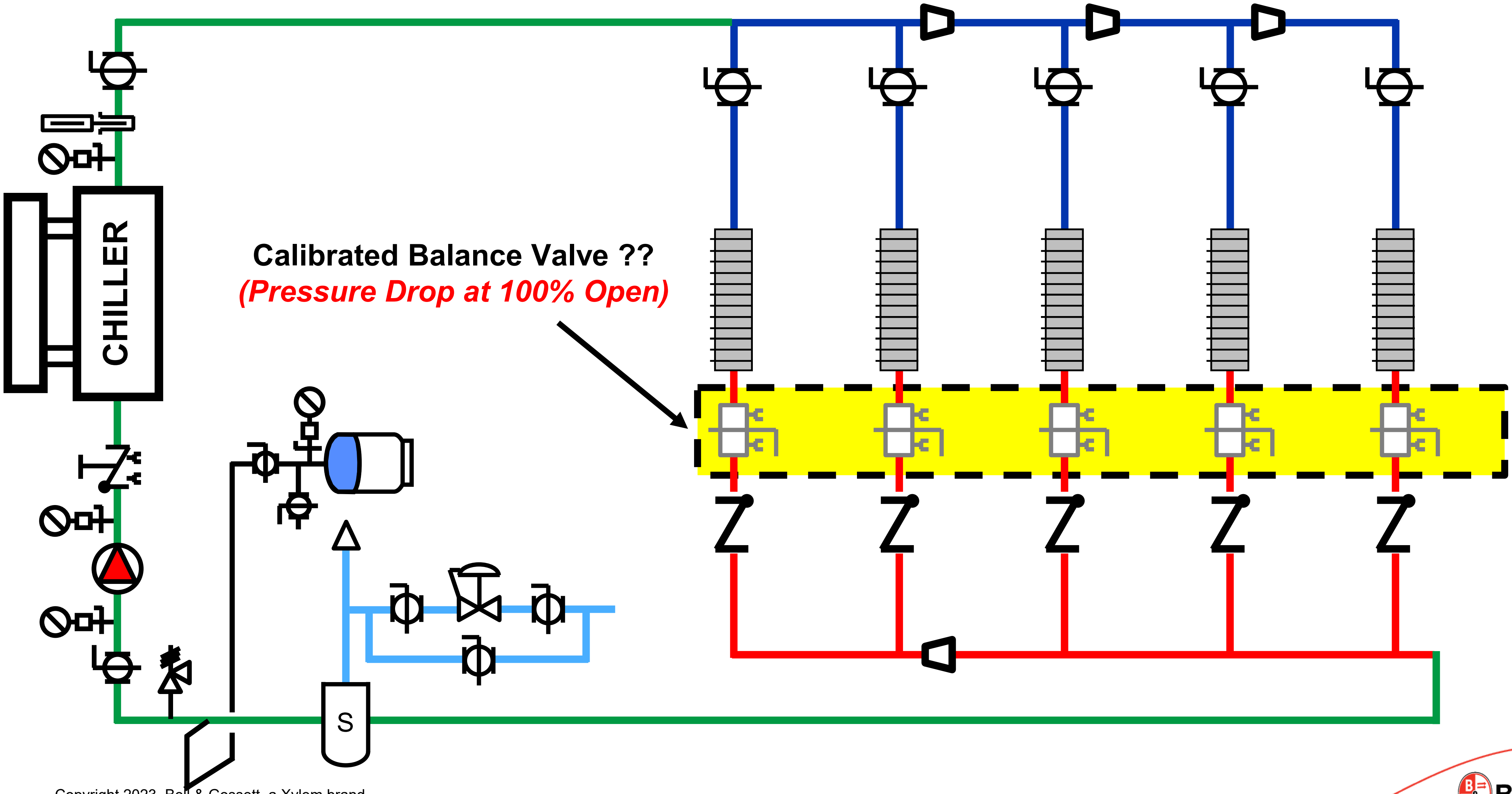
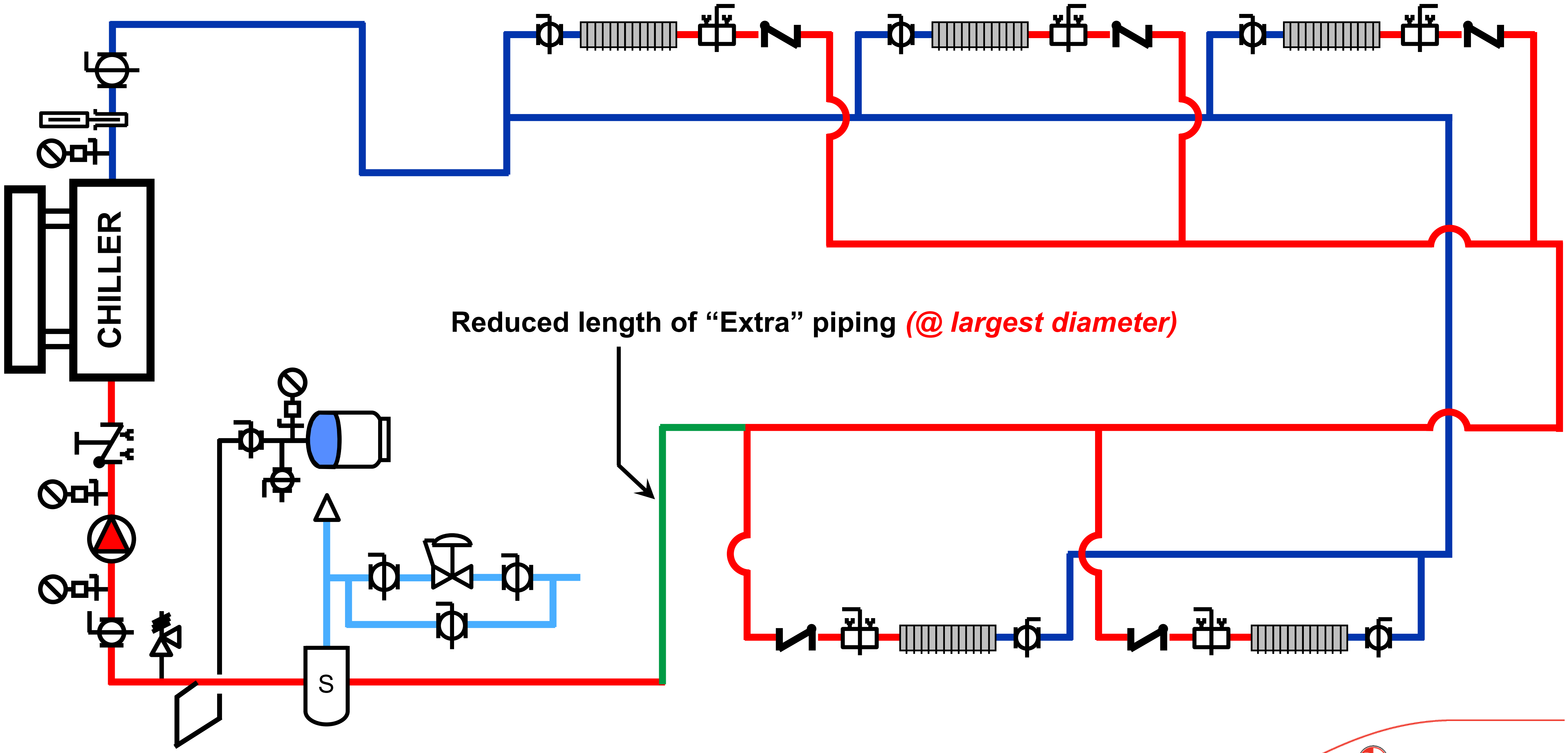
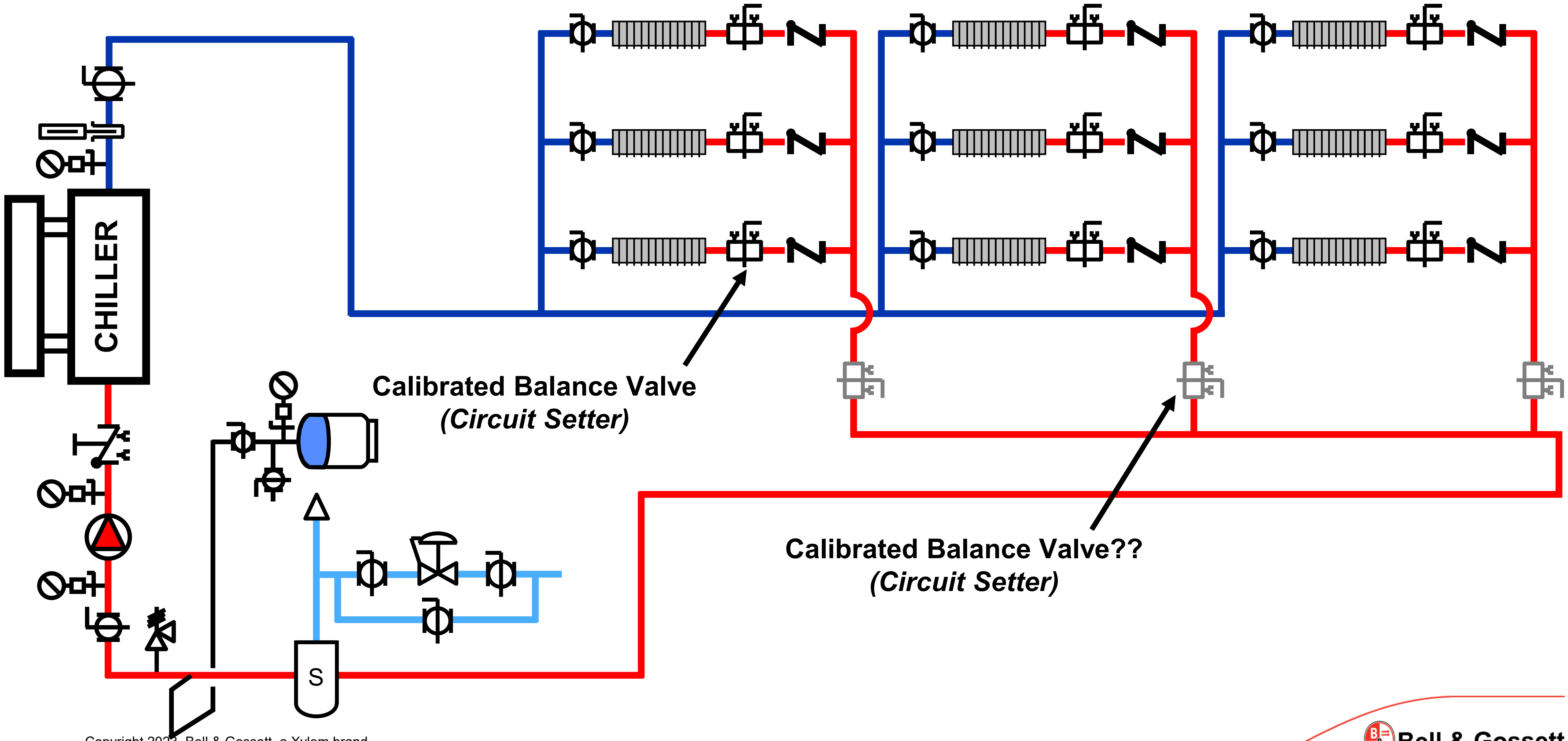
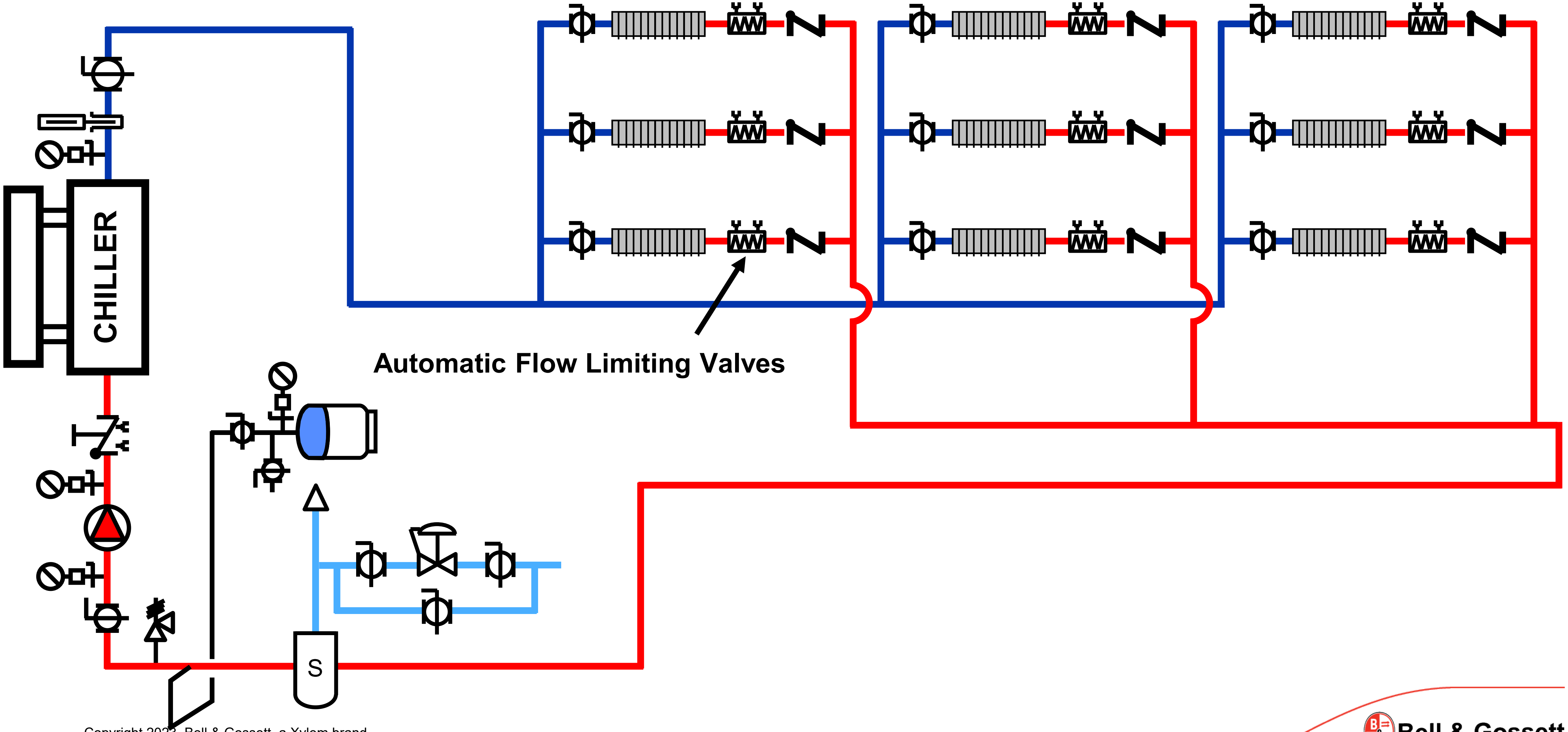

CHILLER
S


CHILLER
Calibrated Balance Valve ??
(Pressure Drop at 100% Open)
S


CHILLER
S
Reduced length of "Extra" piping (@ largest diameter)


CHILLER
Calibrated Balance Valve
(Circuit Setter)
S
Calibrated Balance Valve??
(Circuit Setter)


CHILLER
Automatic Flow Limiting Valves
S

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Primary-Secondary - It's all about "The Pressure Drop"

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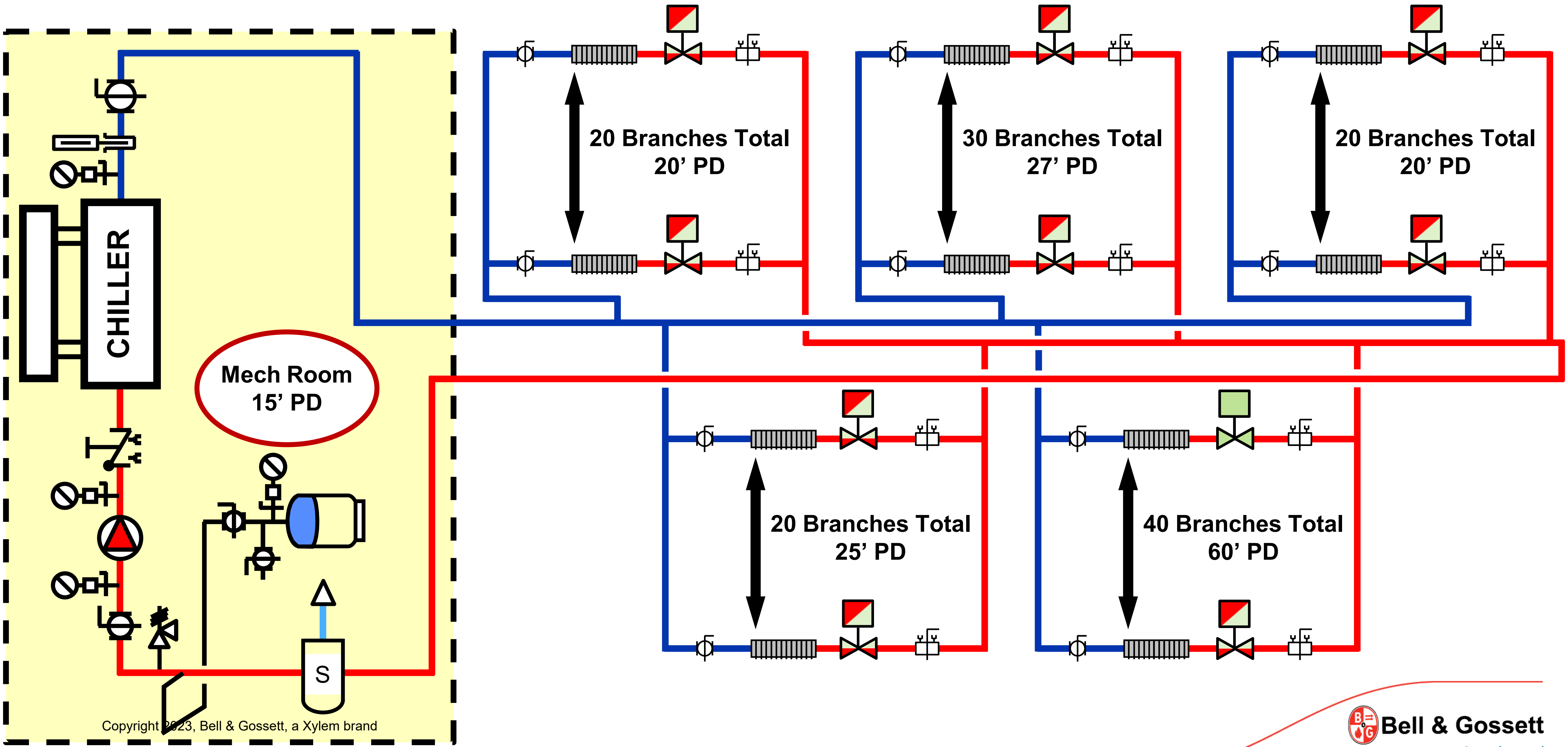
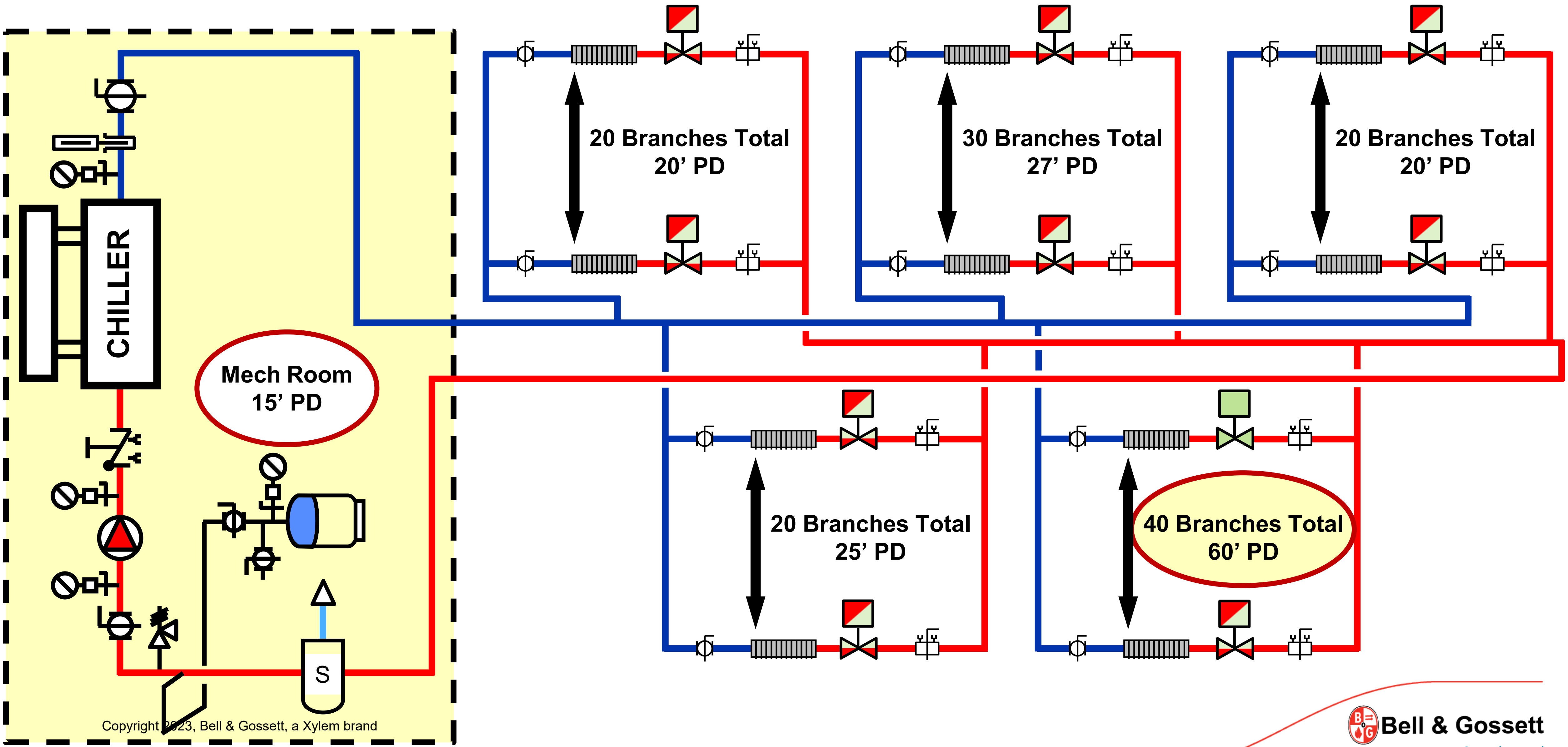
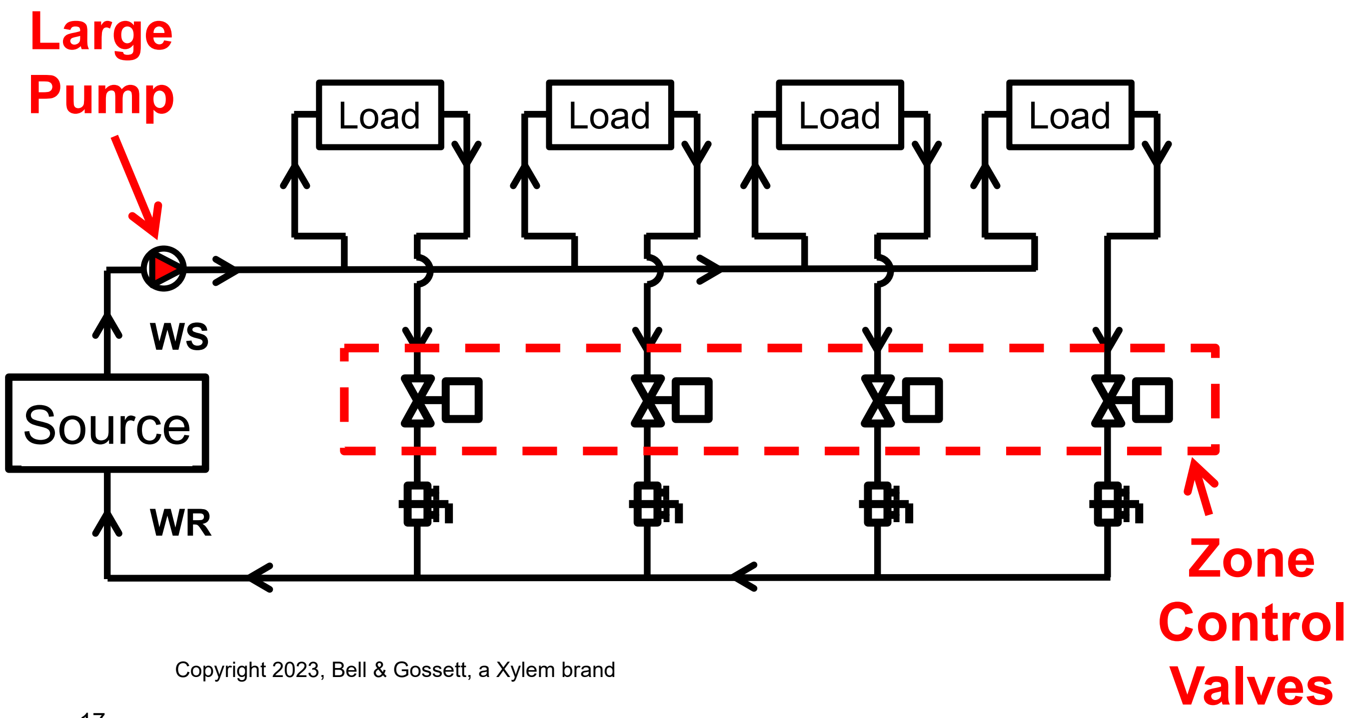
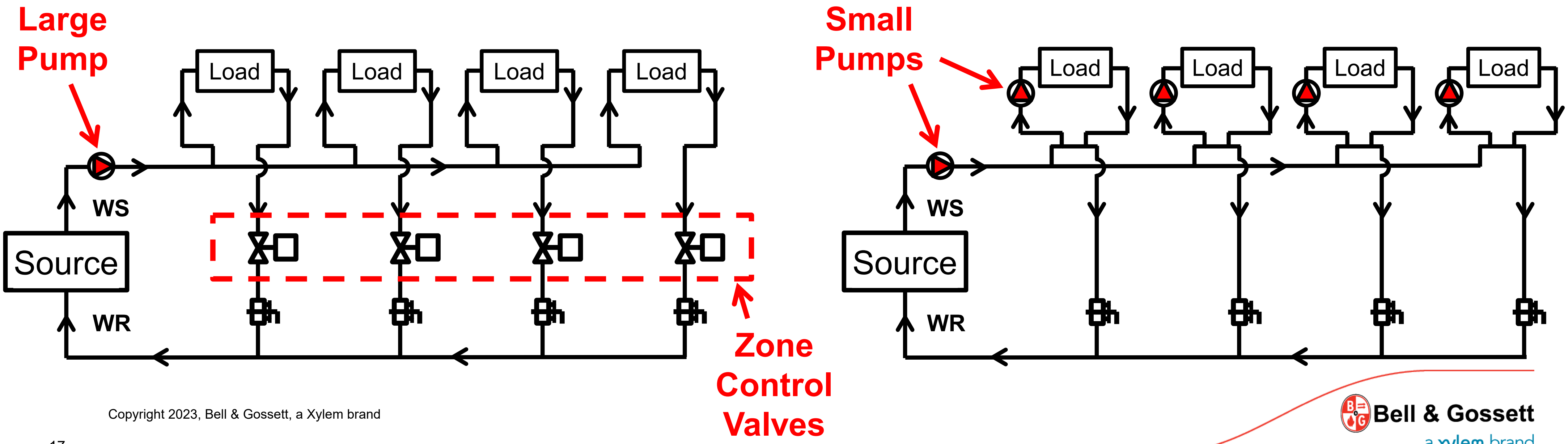

CHILLER
Mech Room
15’ PD
S
20 Branches Total
20’ PD
30 Branches Total
27’ PD
20 Branches Total
20’ PD
20 Branches Total
25’ PD
40 Branches Total
60’ PD

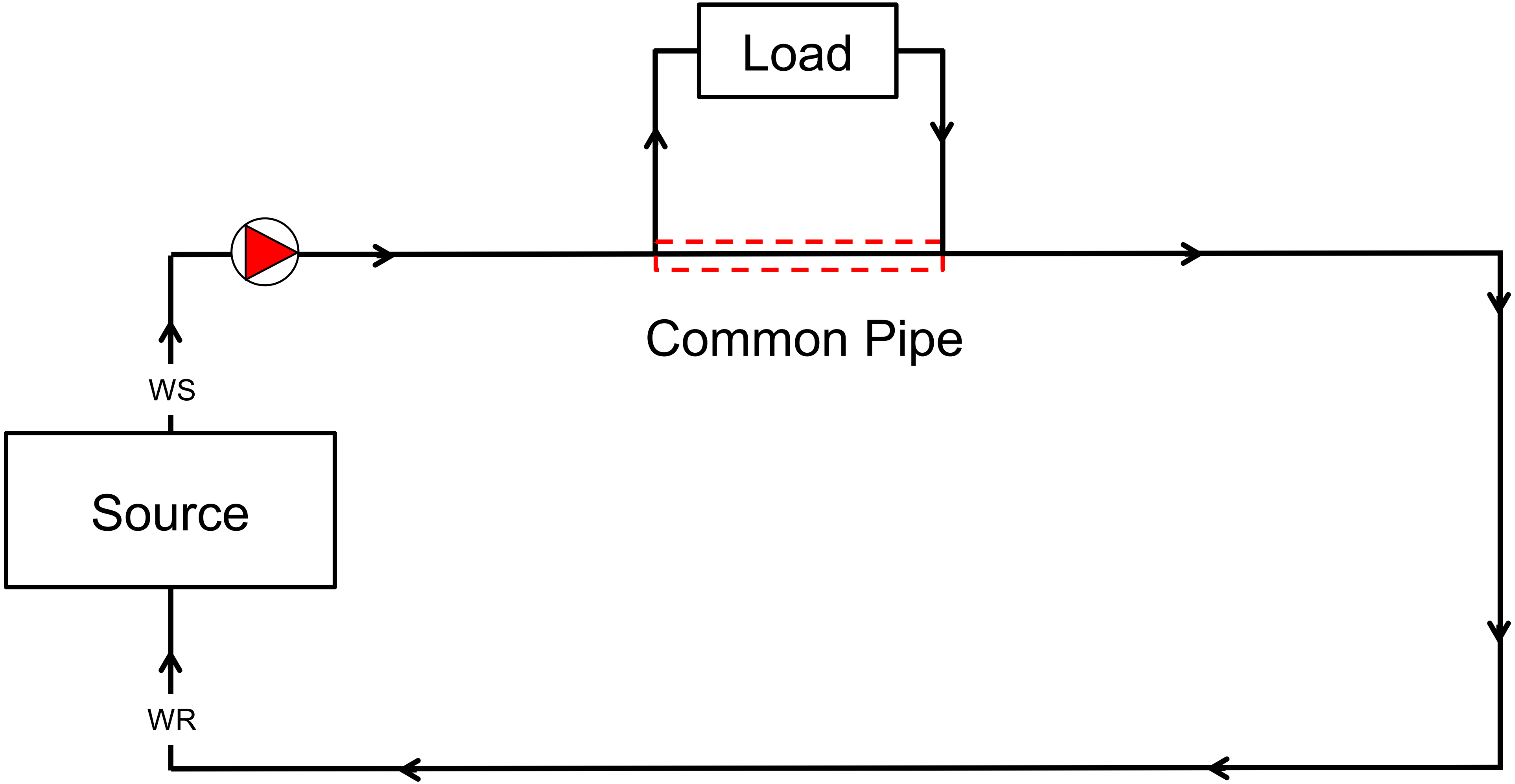

CHILLER
Mech Room
15' PD
S
20 Branches Total
20' PD
30 Branches Total
27' PD
20 Branches Total
20' PD
20 Branches Total
25' PD
40 Branches Total
60' PD

- Converts a Large Complex System into Smaller Manageable Sub-Systems



- Converts a Large Complex System into Smaller Manageable Sub-Systems
- Hydraulically Isolates One System from the Other
- Can Provide Thermal Separation





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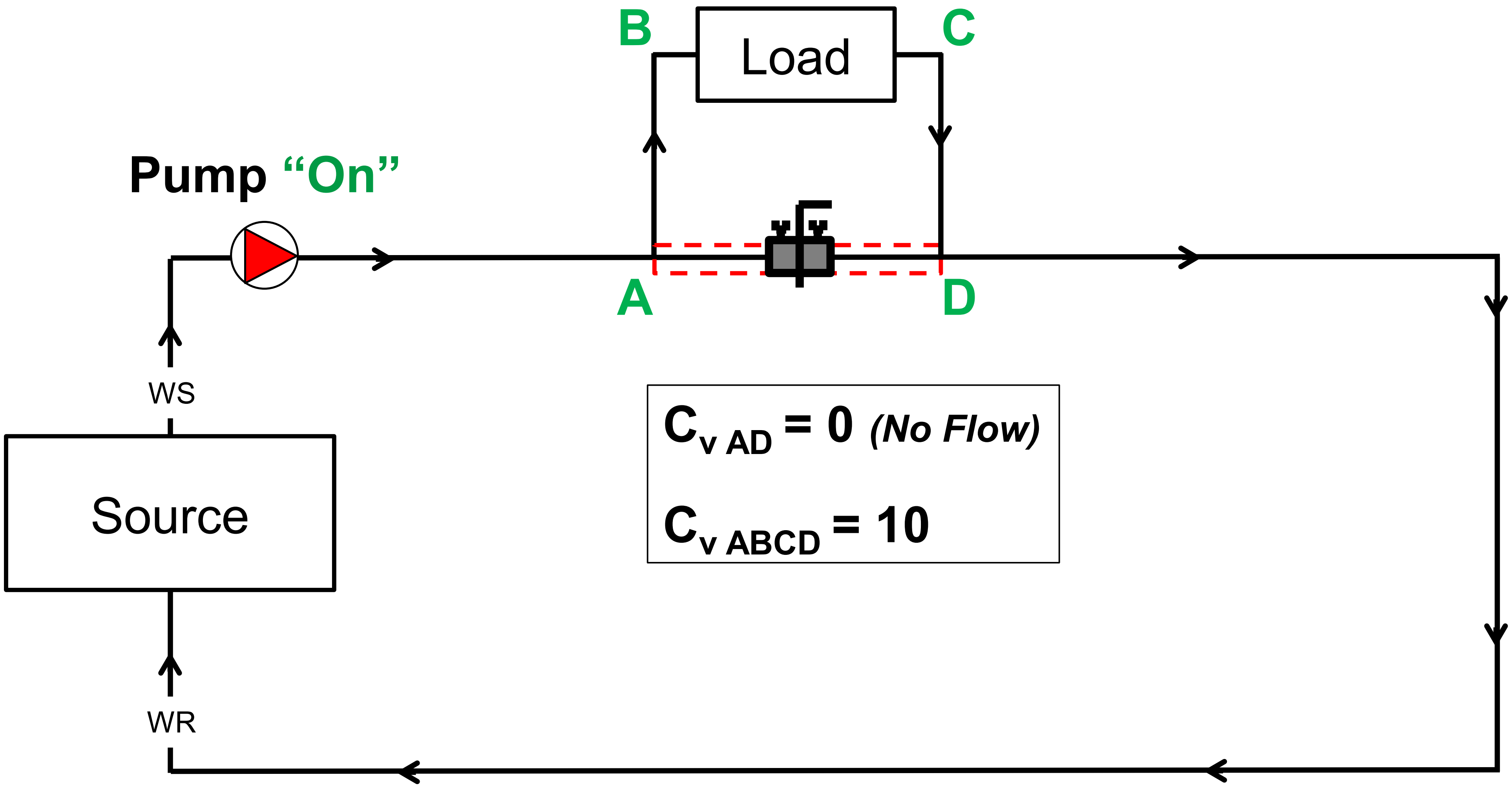
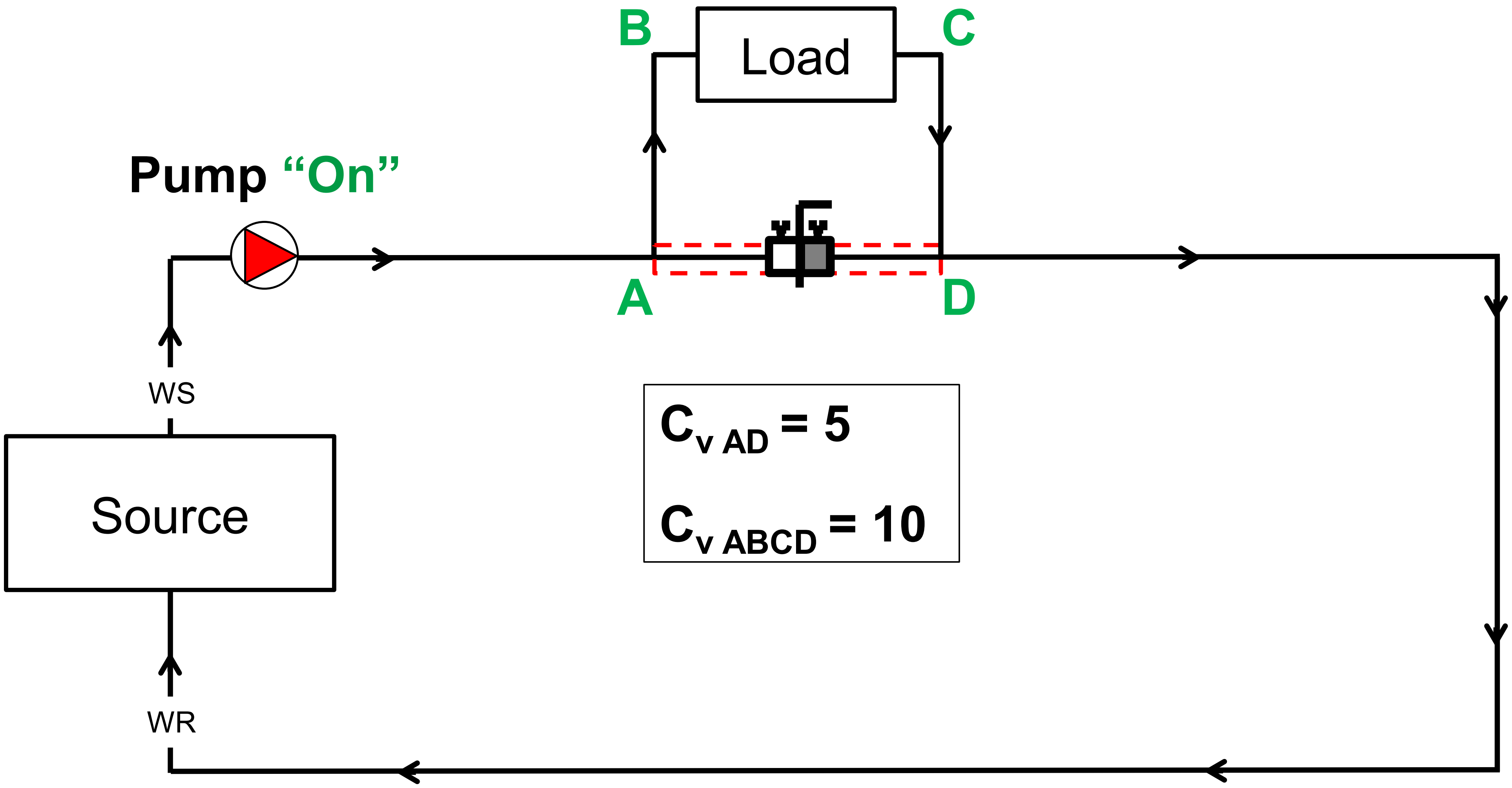


$C_{v\ AD} = 0$ *(No Flow)*

$C_{v\ ABCD} = 10$

Pressure Drop in Common Pipe – Valve 50% Closed



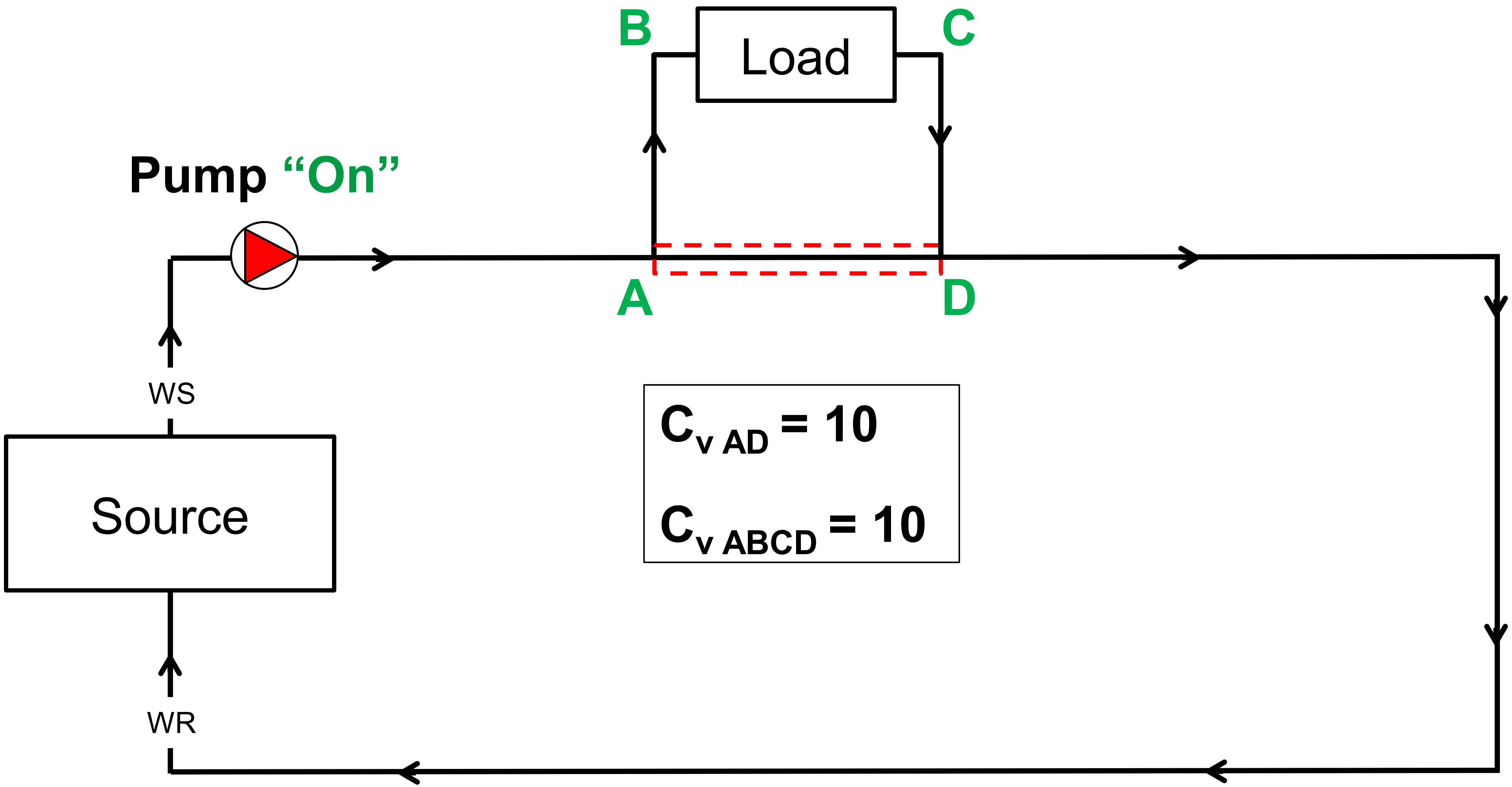
$C_{v\ AD} = 5$

$C_{v\ ABCD} = 10$

C_v Definition: Flow, in **GPM**, Across an Open Valve when a Constant Pressure **Differential of 1 PSI** is Maintained.

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

Pressure Drop in Common Pipe – Valve Removed



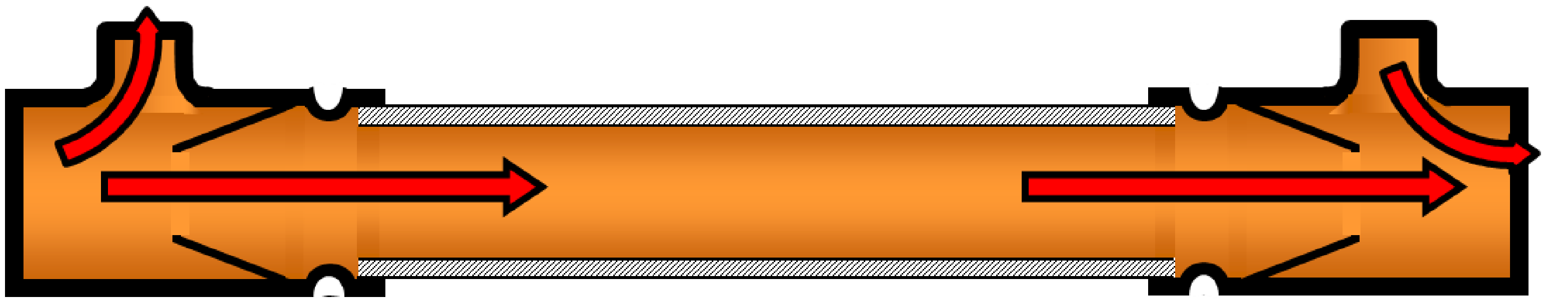
$C_{v\ AD} = 10$

$C_{v\ ABCD} = 10$

When Two Piping Circuits are Inter-Connected,

Flow in One Circuit ***Will*** Cause Flow in the Other,

To a Degree, Depending Upon the **Pressure Drop** in the Piping Common to Both.



Common Pipe

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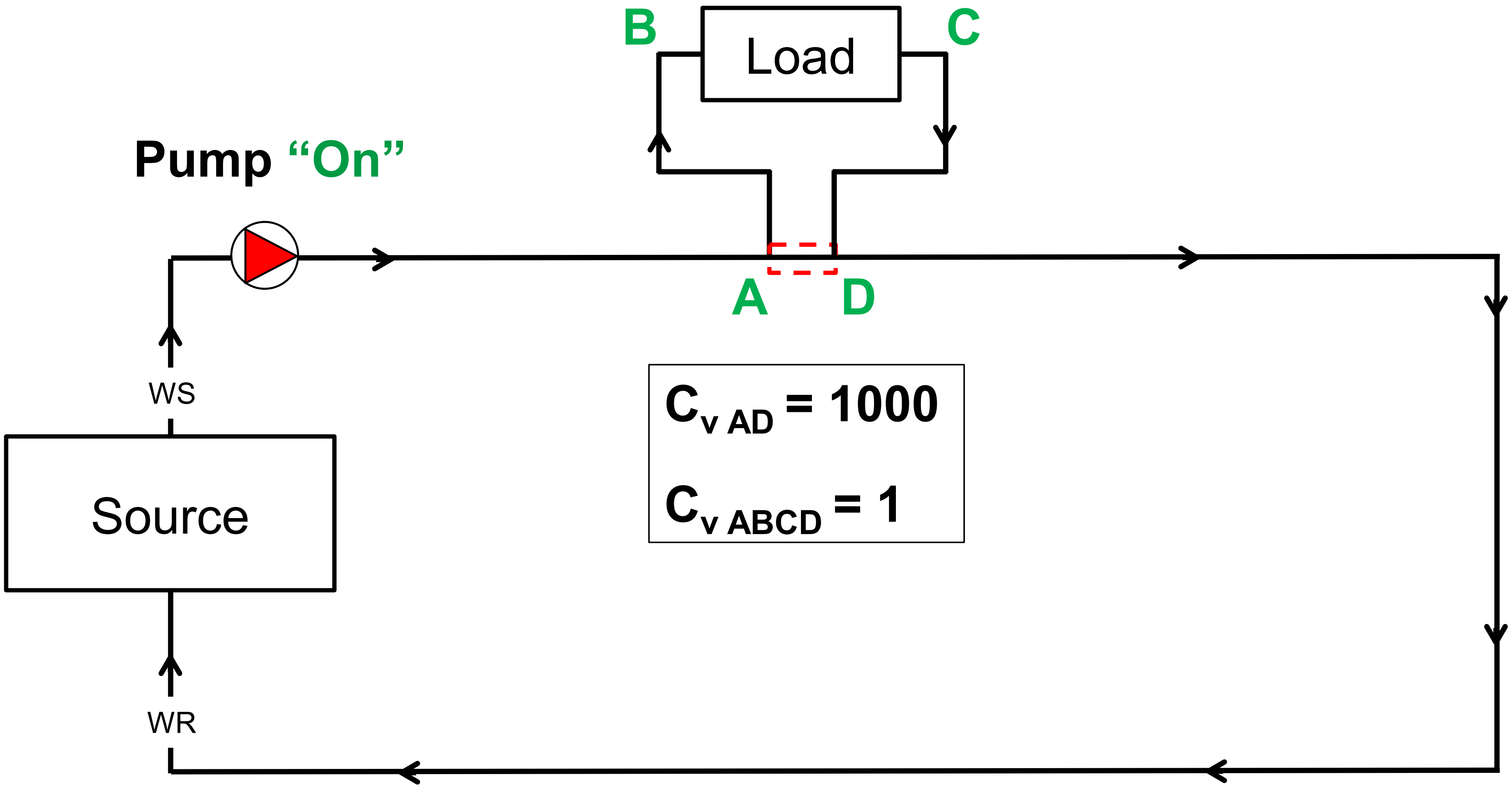


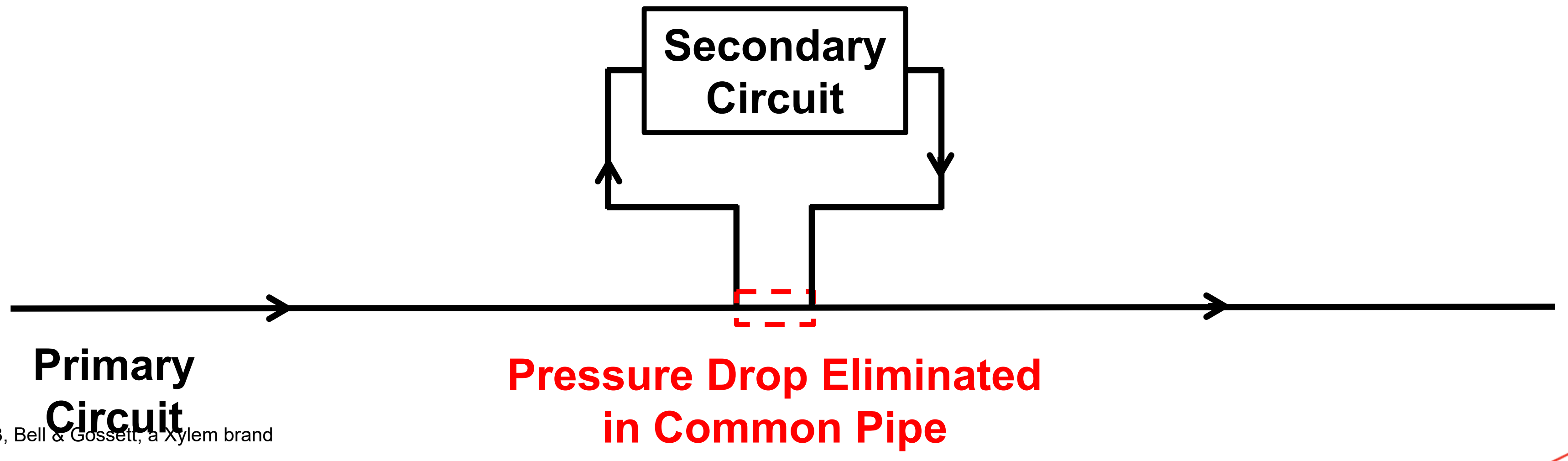
$C_{v\ AD} = 1000$

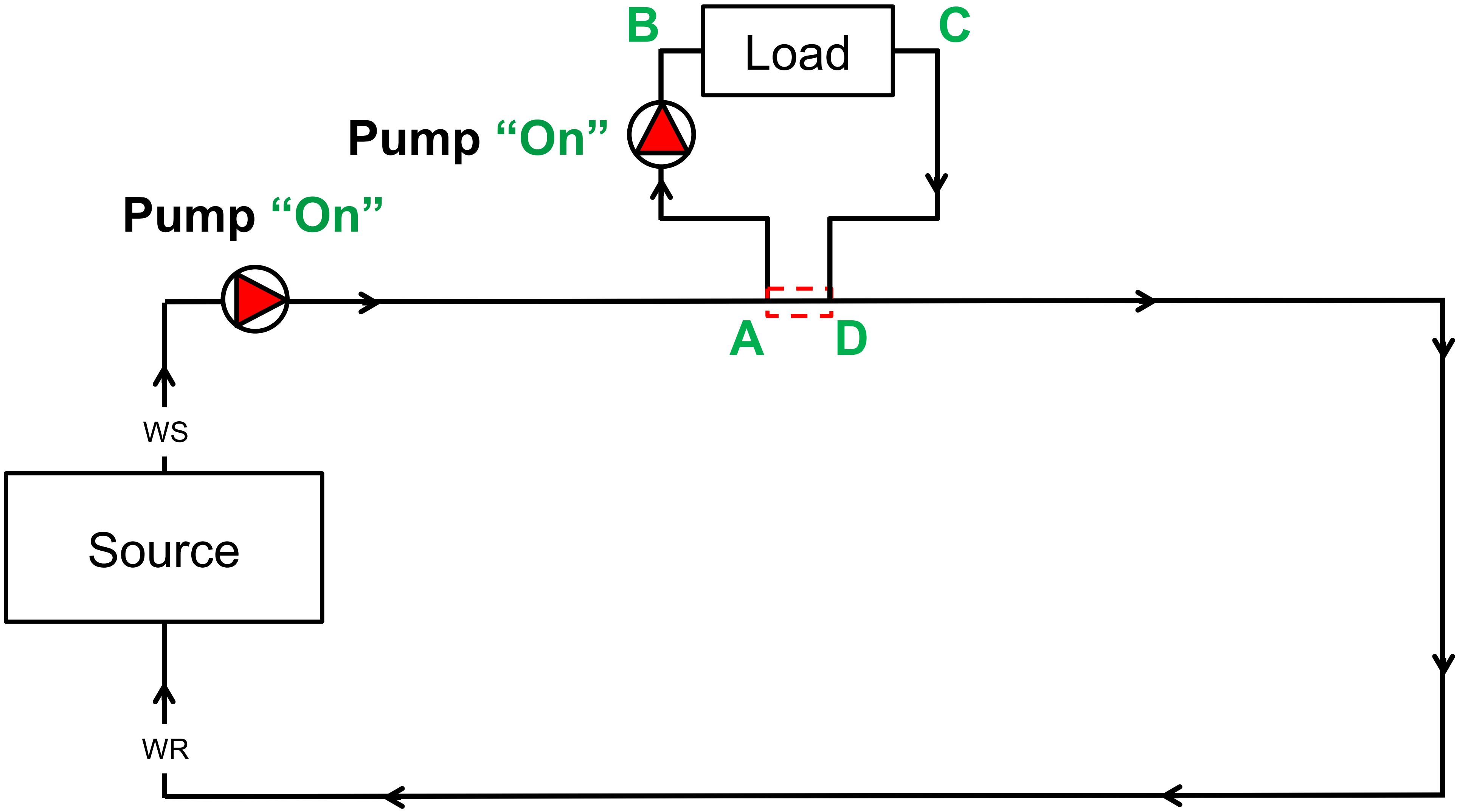
$C_{v\ ABCD} = 1$

When Two Piping Circuits are Inter-Connected,

Flow in One Circuit Will ***Not*** Cause Flow in the Other,

If the **Pressure Drop** in the Piping Common to Both is **Eliminated**.

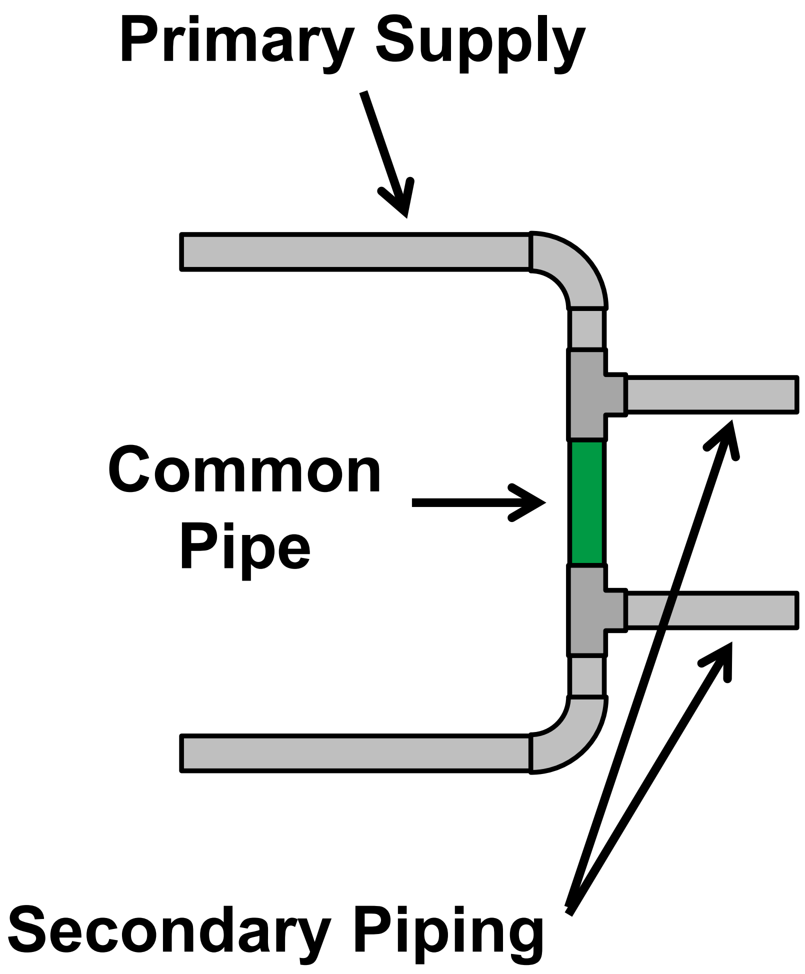



B
Load
C
Pump "On"
Pump "On"
A
D
WS
Source
WR

- Three to Four Pipe Diameters Between Tees
  (Recommend no less than 12”)

- Head Loss Less Than **1.5 Feet**
  (Recommend size equal to Primary Supply)

- Keep Velocities Low in Secondary Piping
  (Recommend 2-4 FPS for air control and noise)



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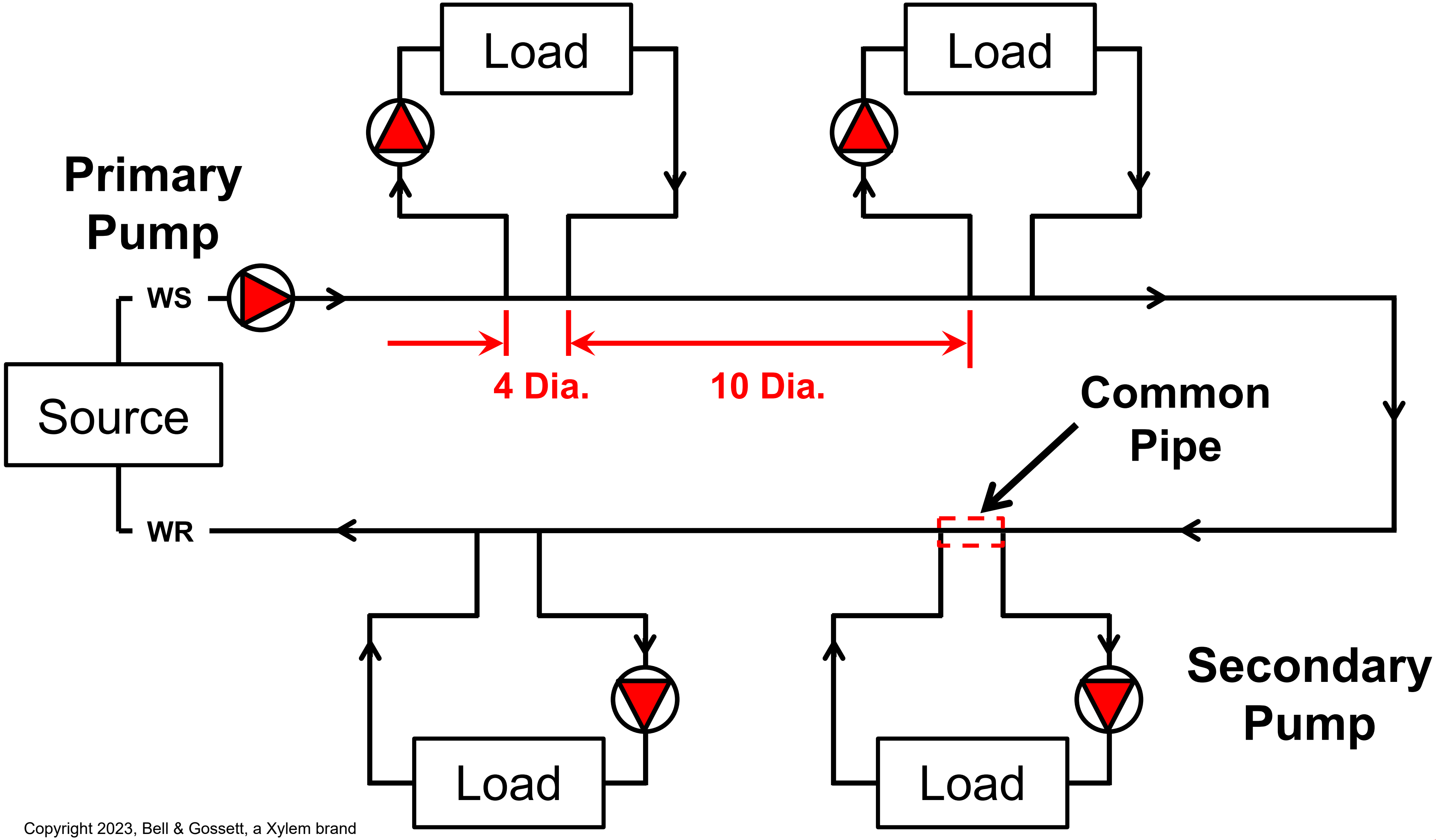
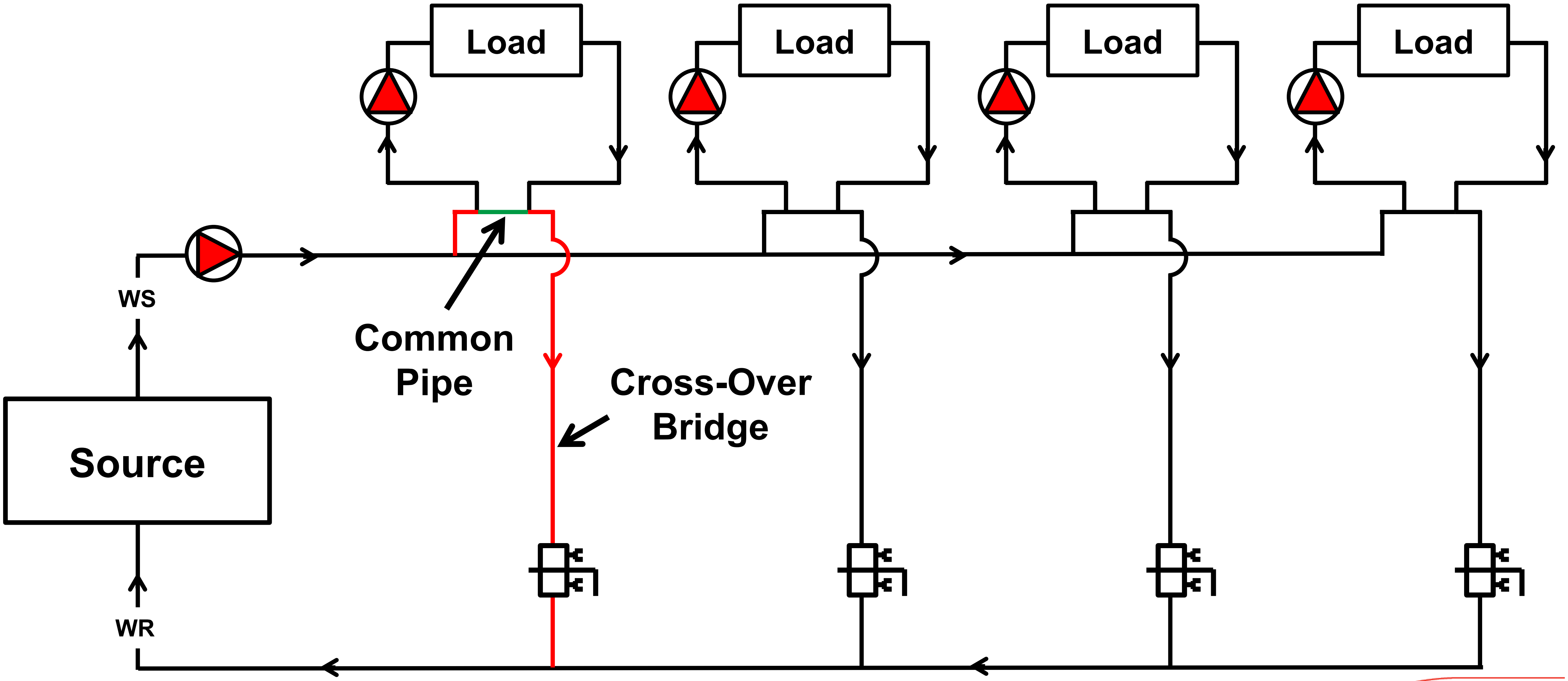
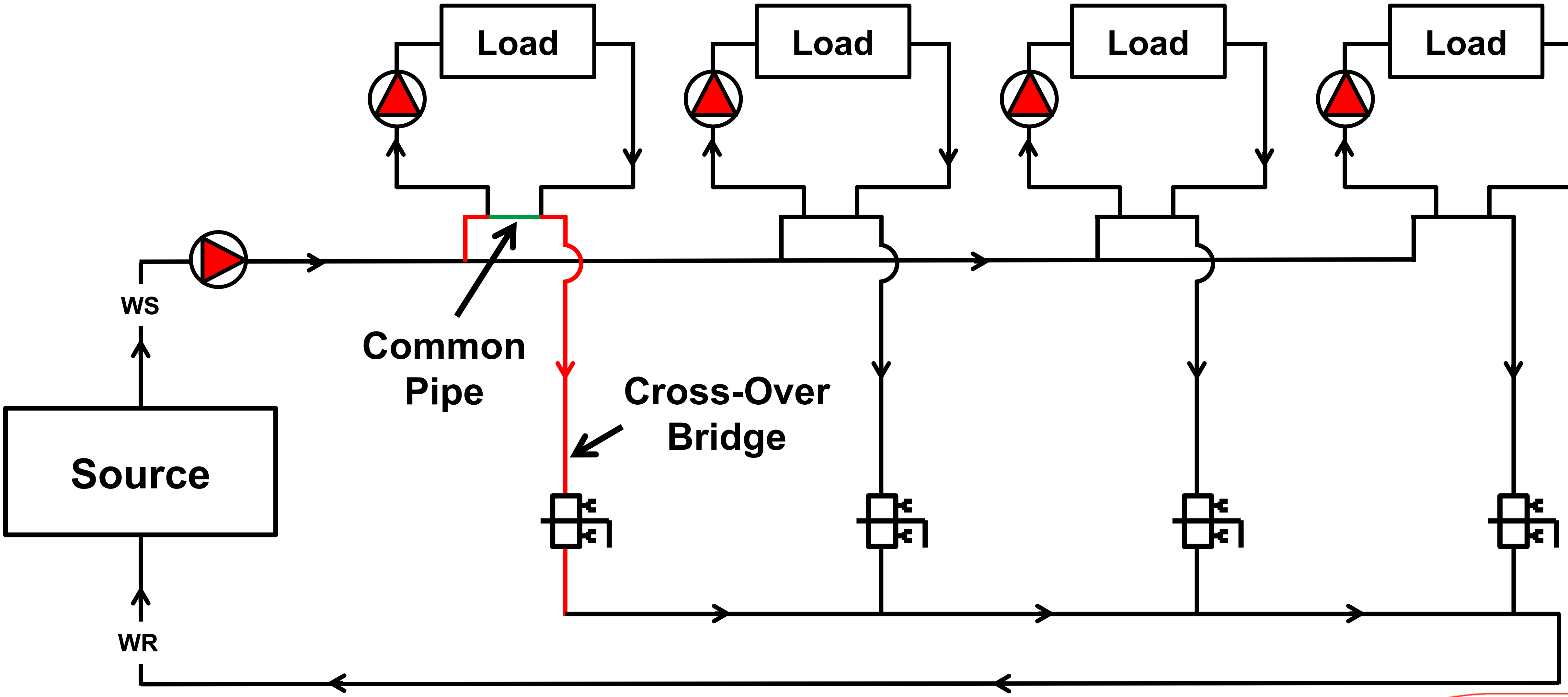

Load
Load
Primary
Pump
WS
4 Dia.
10 Dia.
Common
Pipe
Source
WR
Secondary
Pump
Load
Load

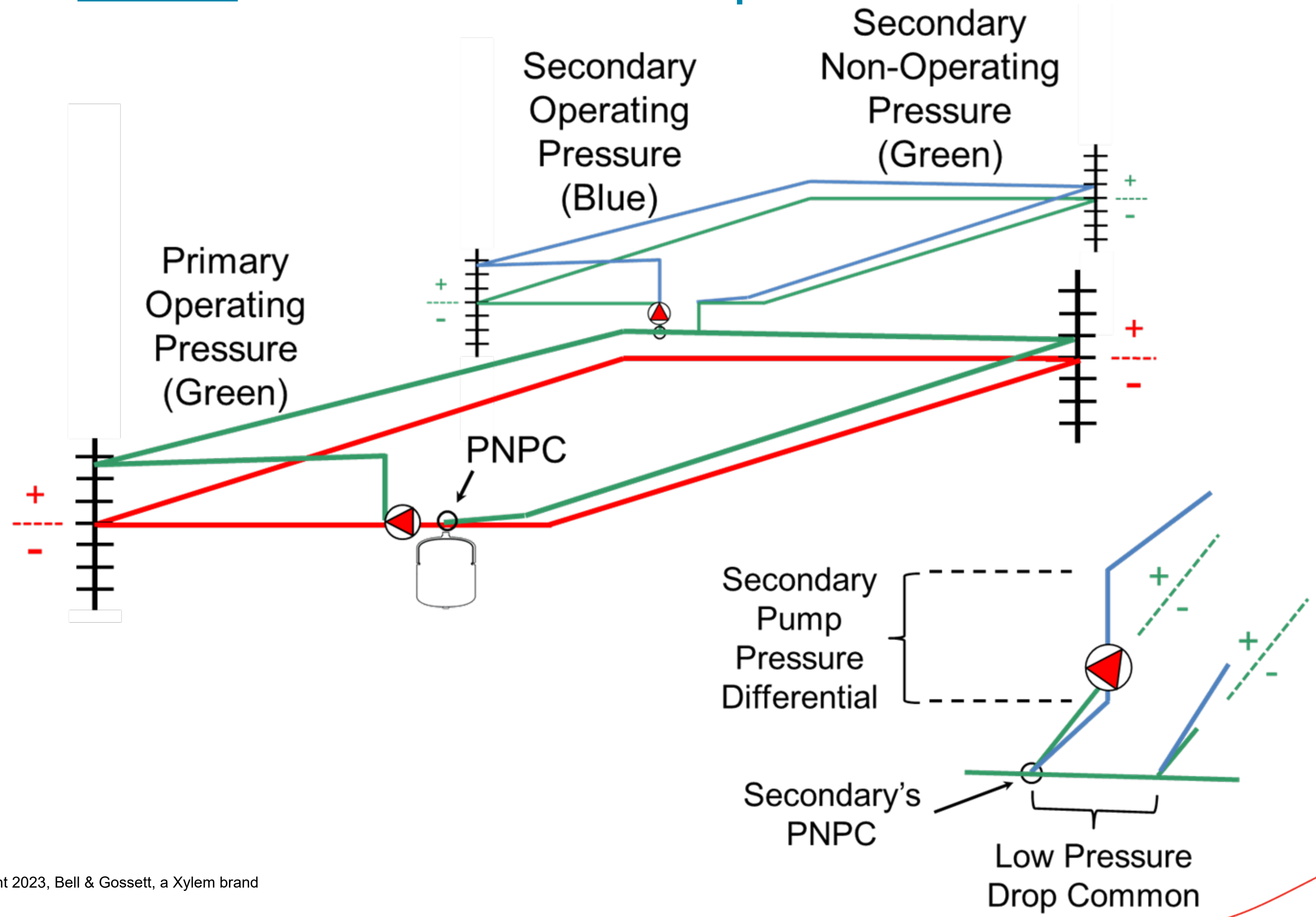
Primary-Secondary System



Primary-Secondary System



_____ From Common Pipe



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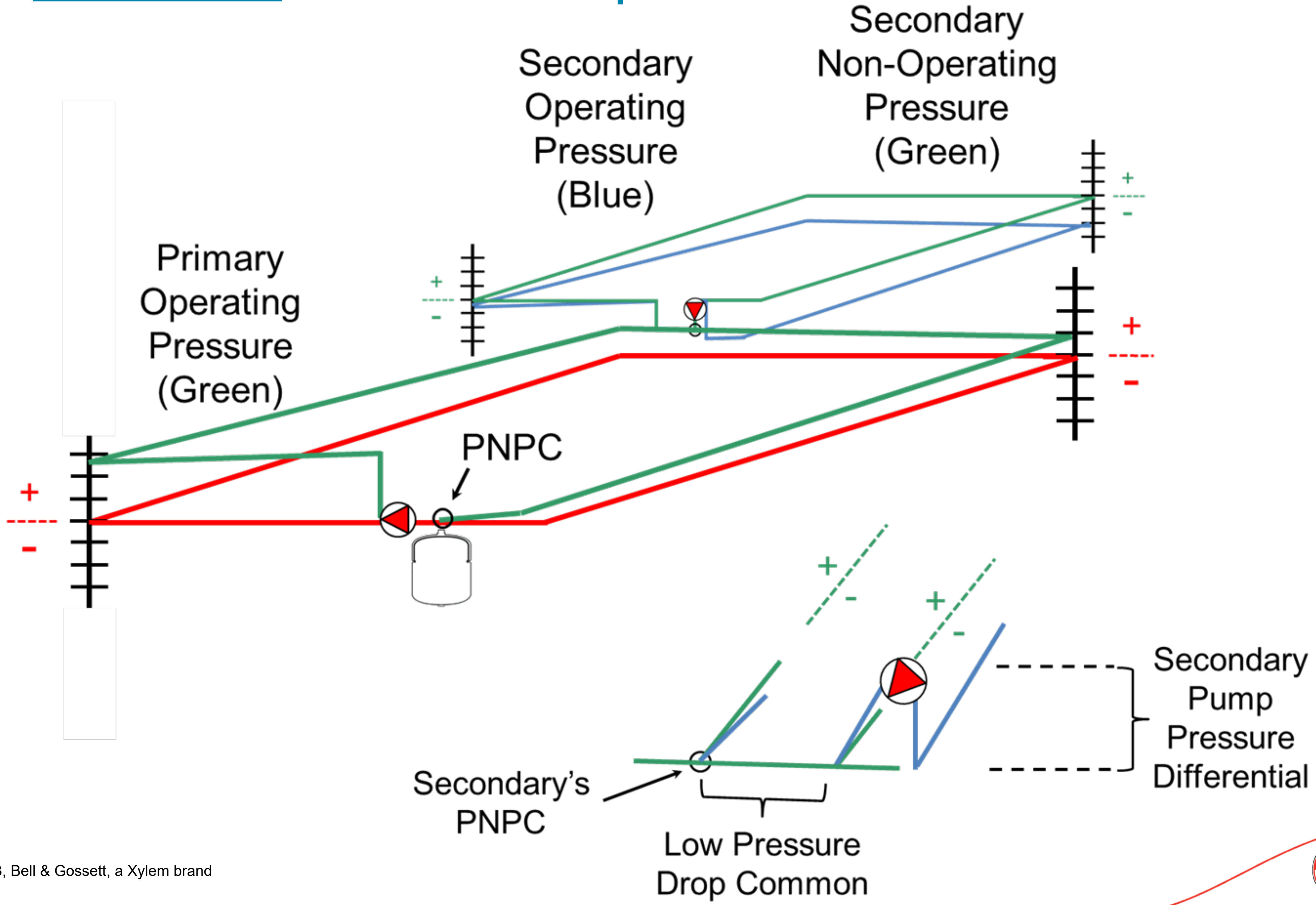
________ Common Pipe



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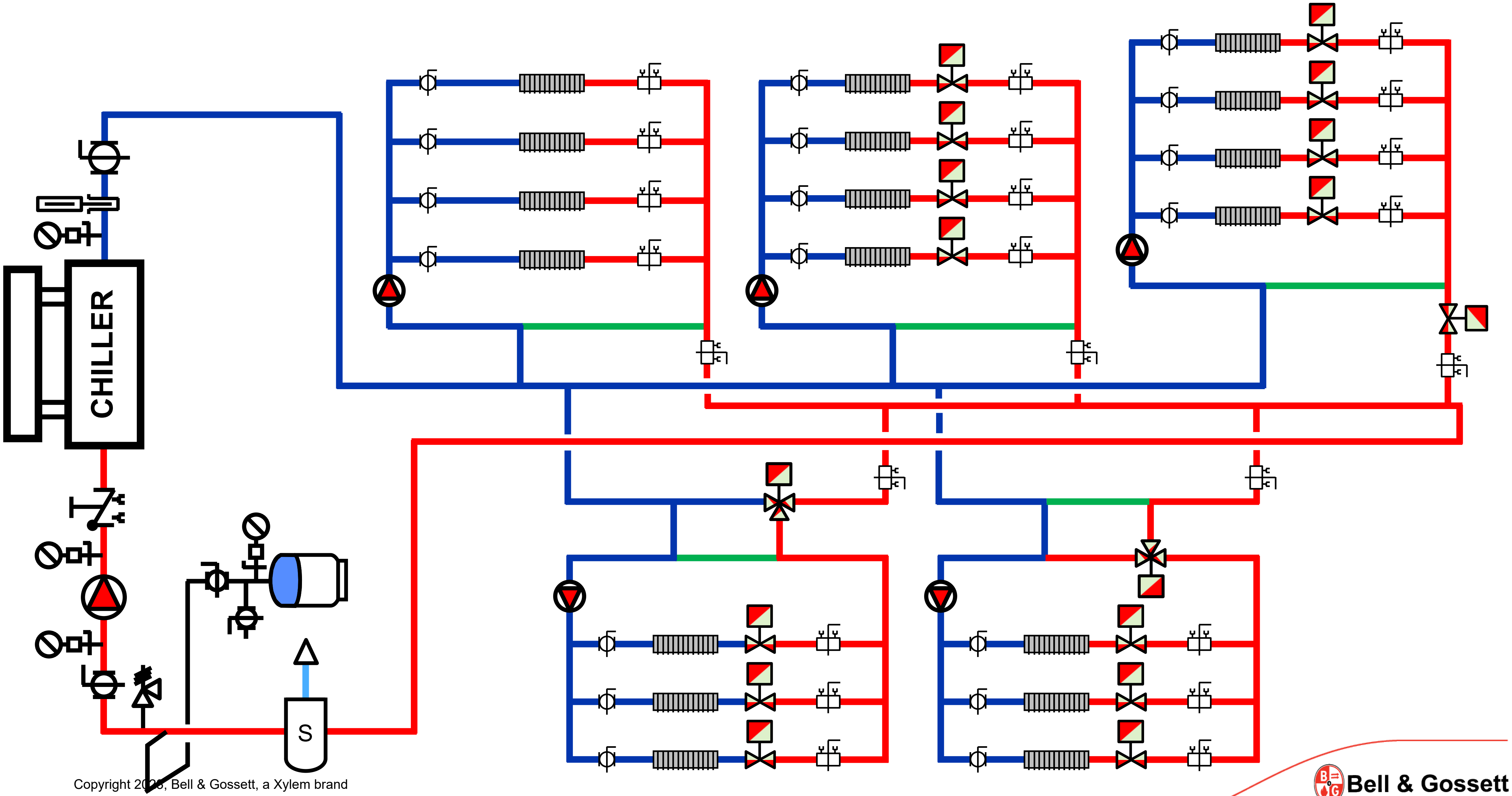
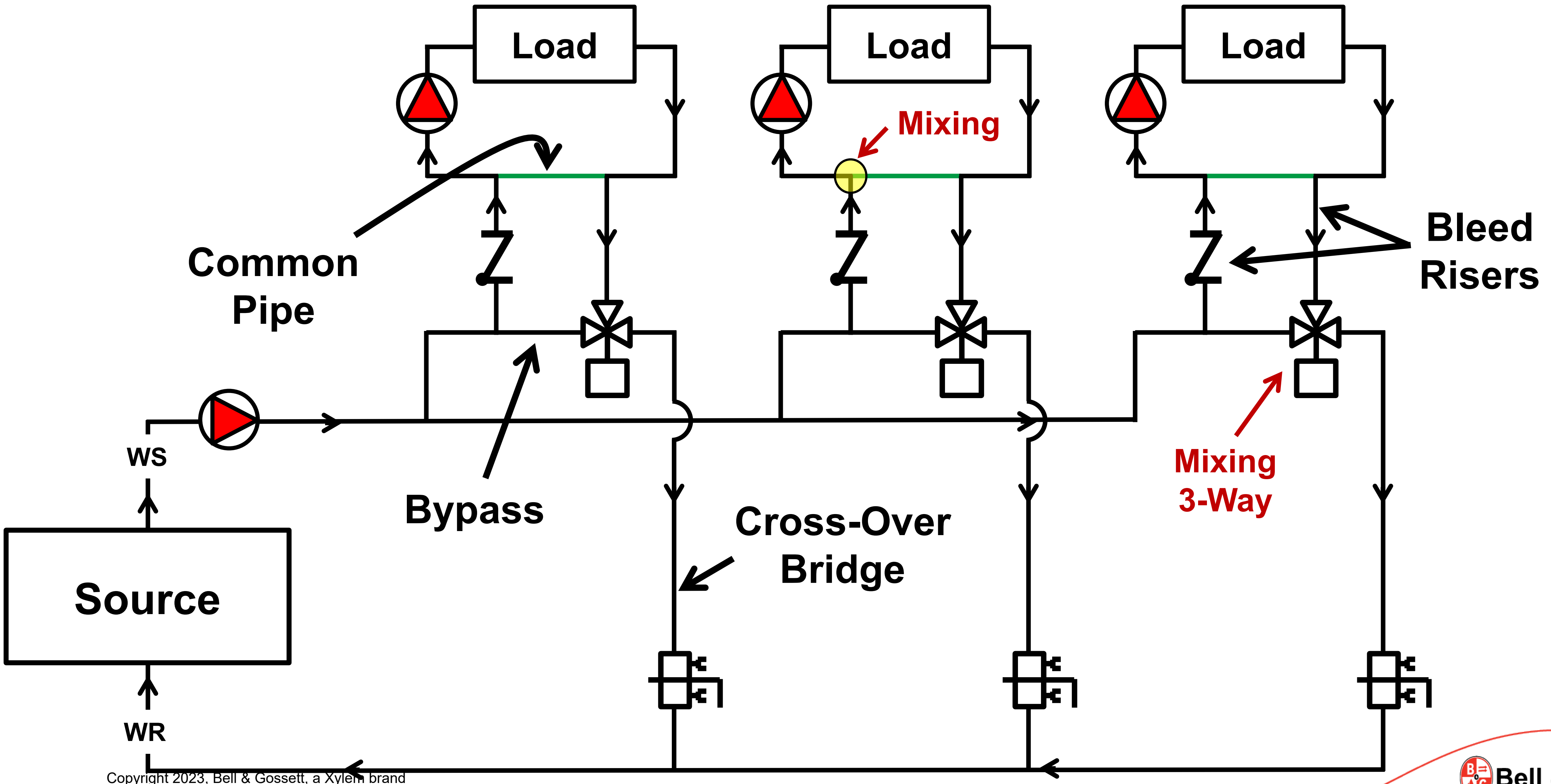

CHILLER
S

Continuous Secondary Pump Circulation



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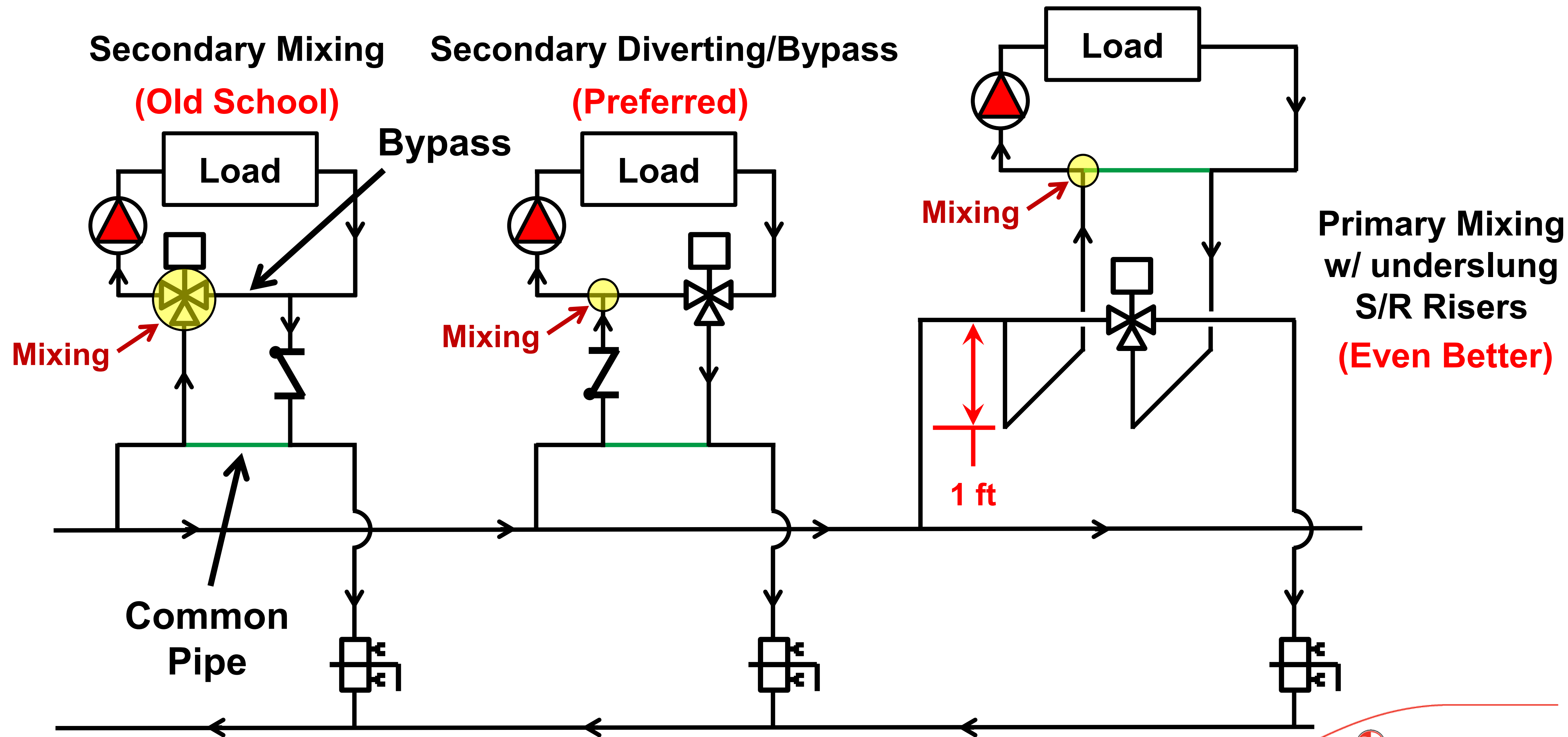
Continuous Secondary Pump Circulation



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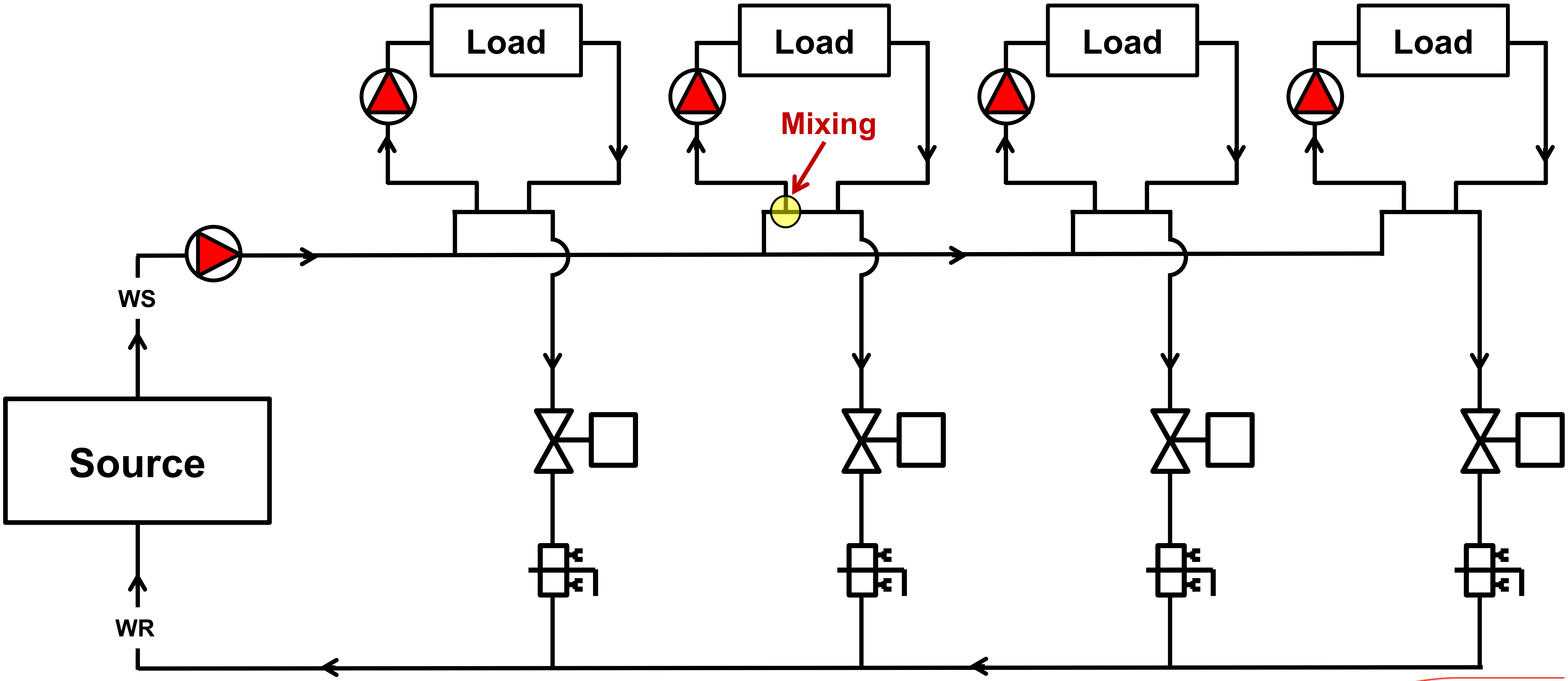
Primary-Secondary Modulating 2-Way Valve Control

Source Pump Variable Speed Control possible



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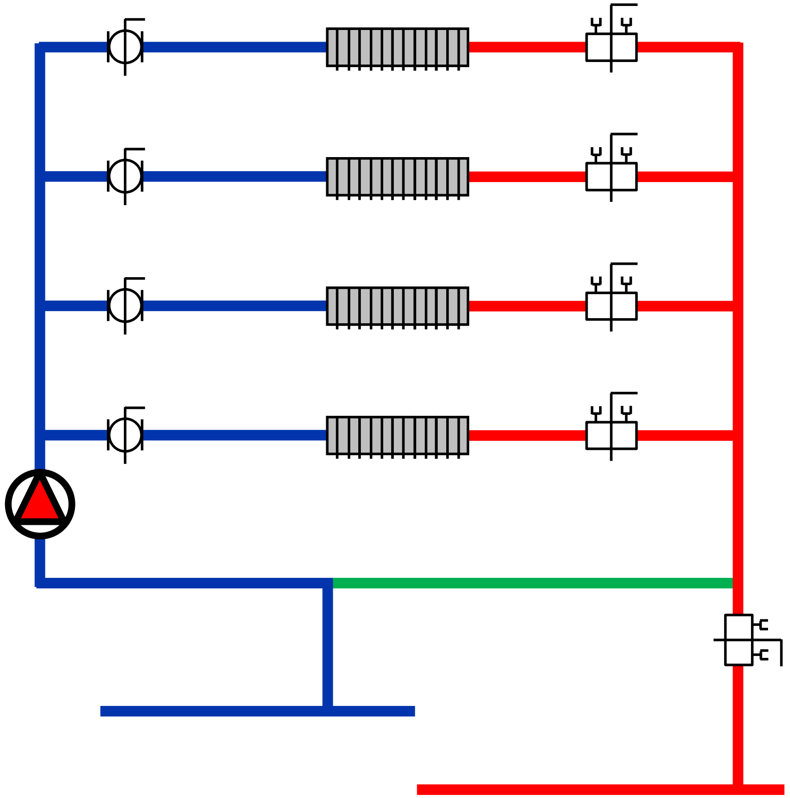
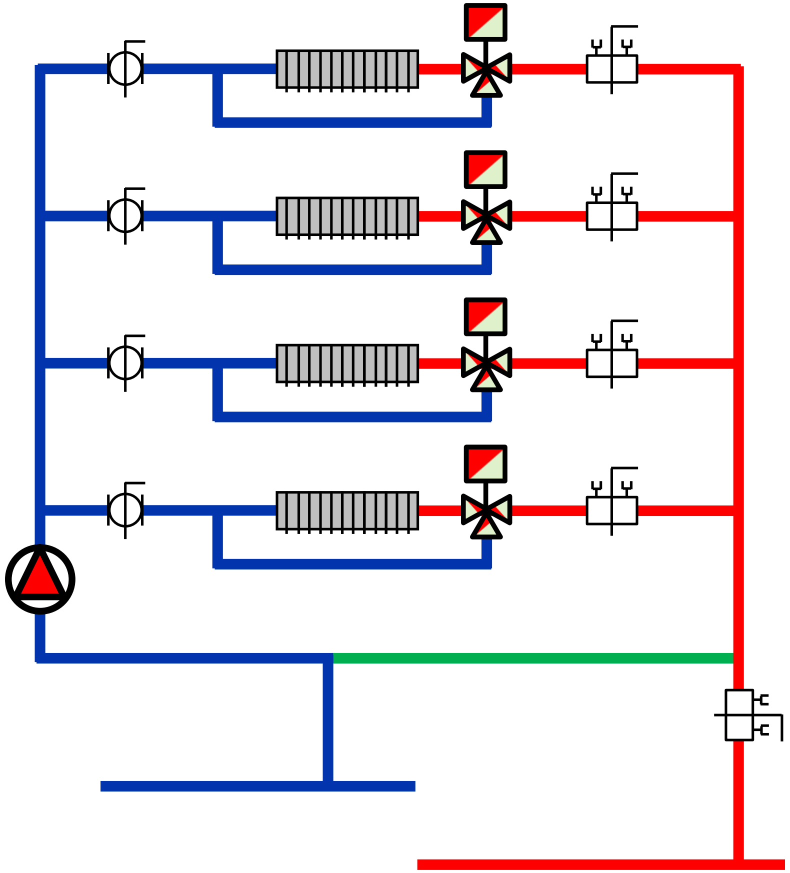
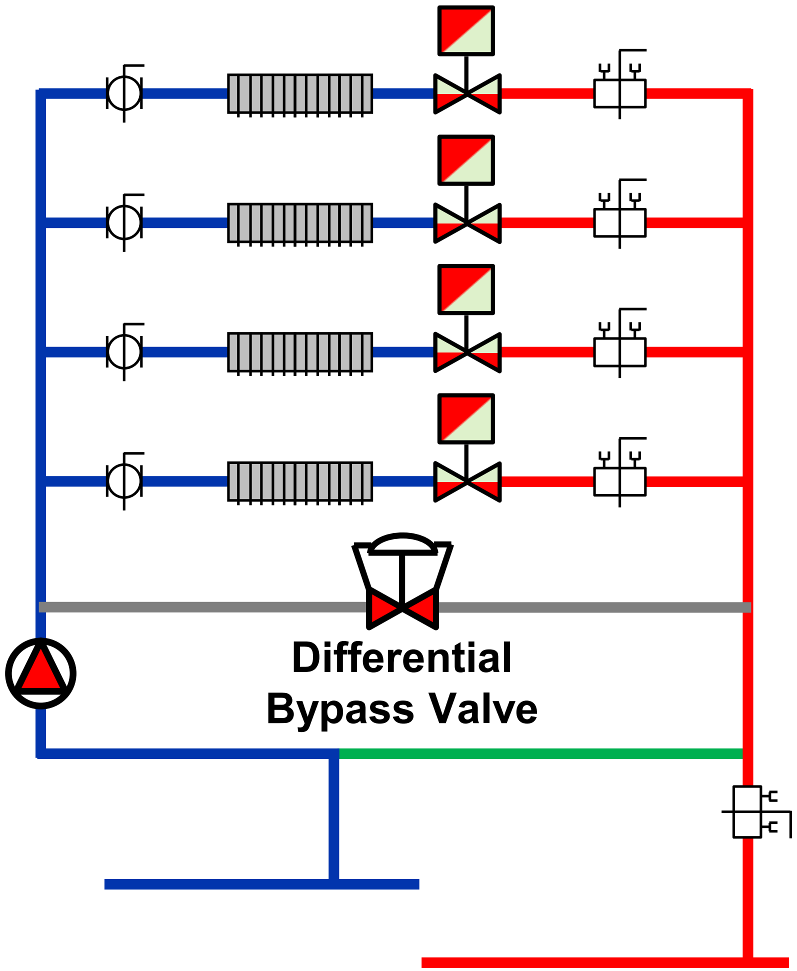


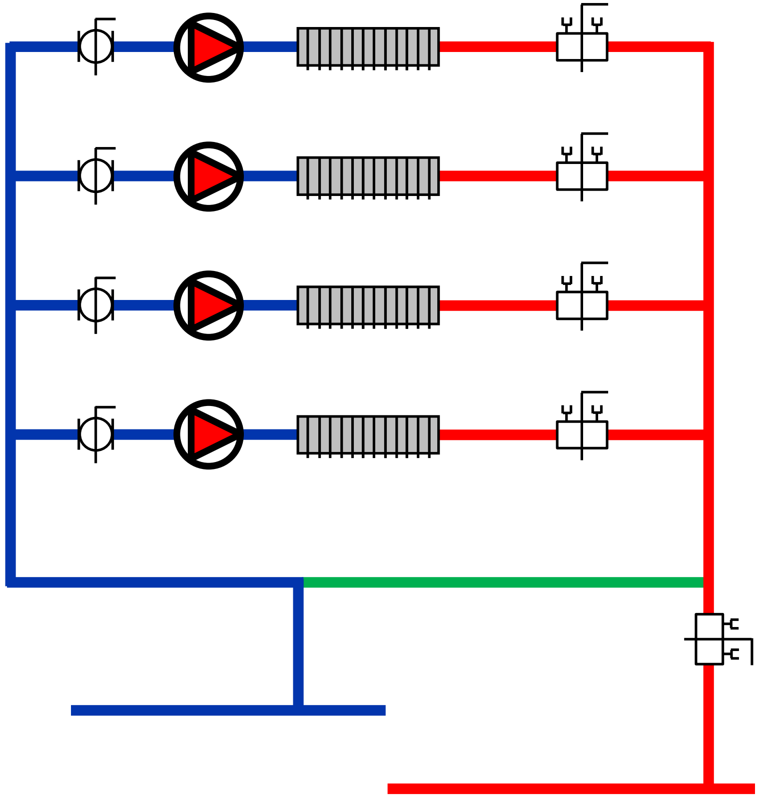
Constant Secondary Flow
(“On/Off” Pump Control)

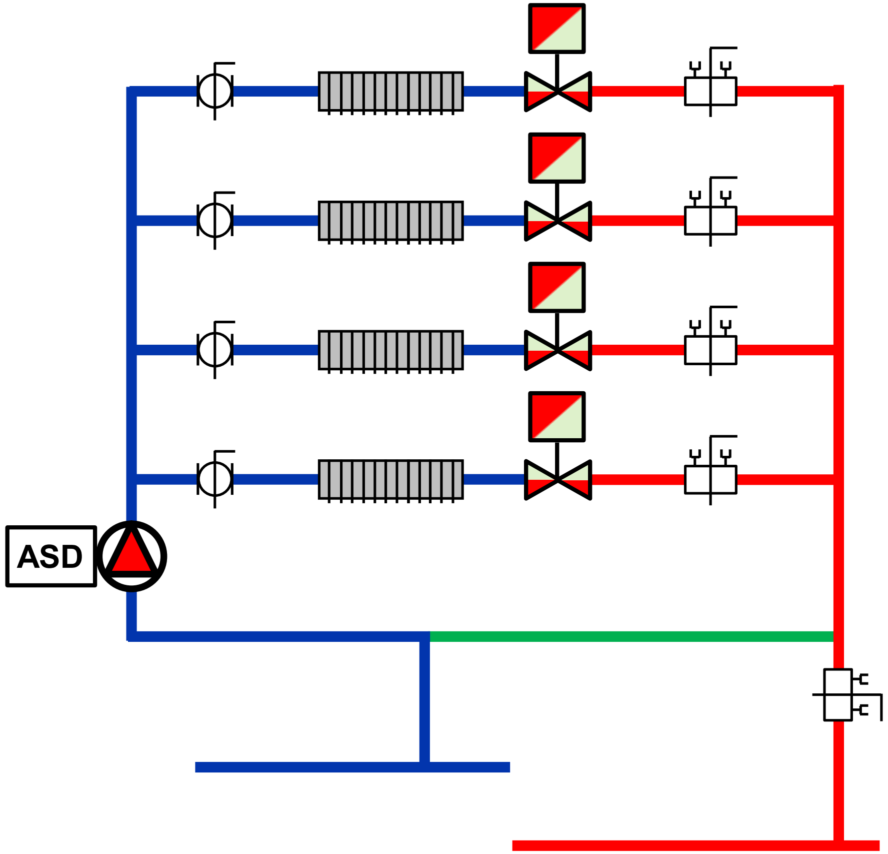


Constant Secondary Flow
(Continuous Pump)



Variable Secondary Flow
(Continuous Pump)

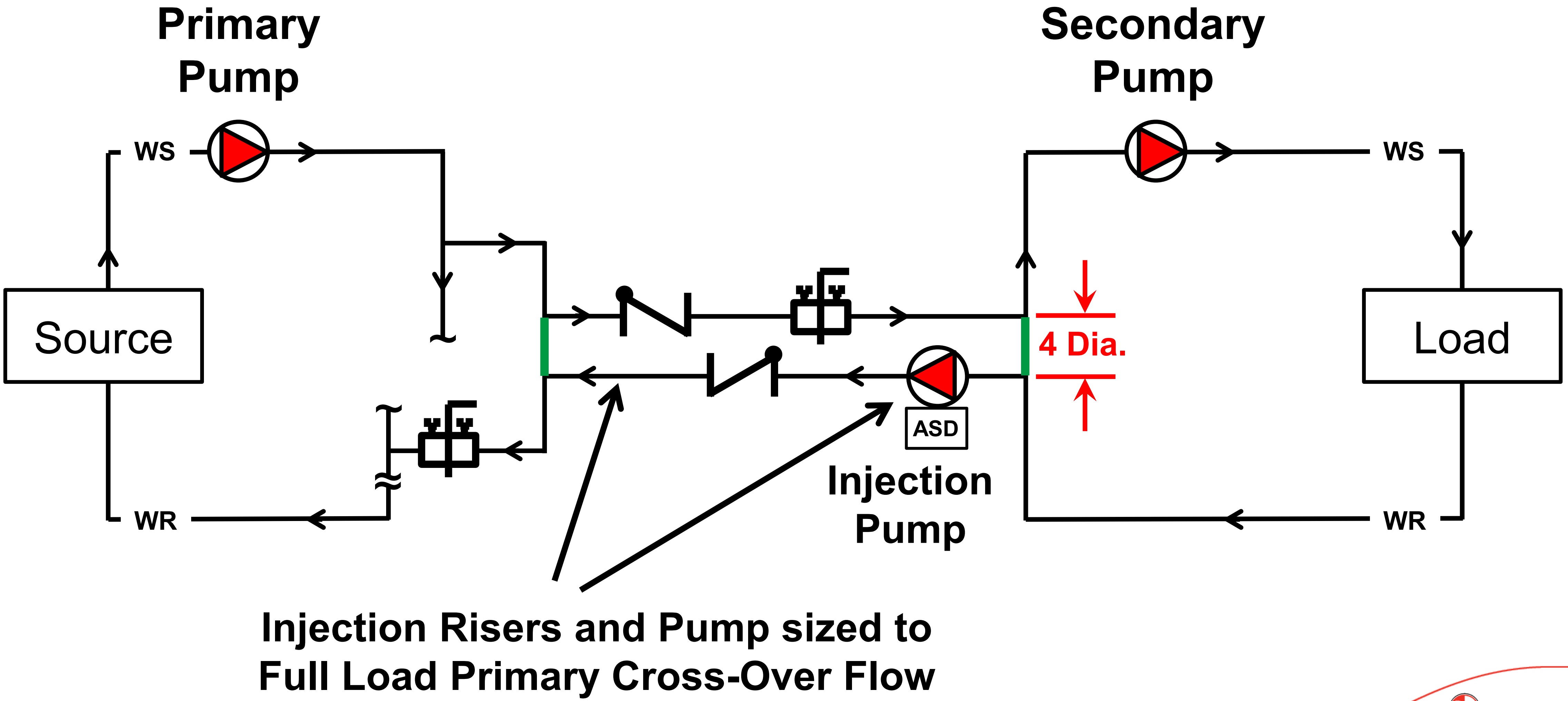




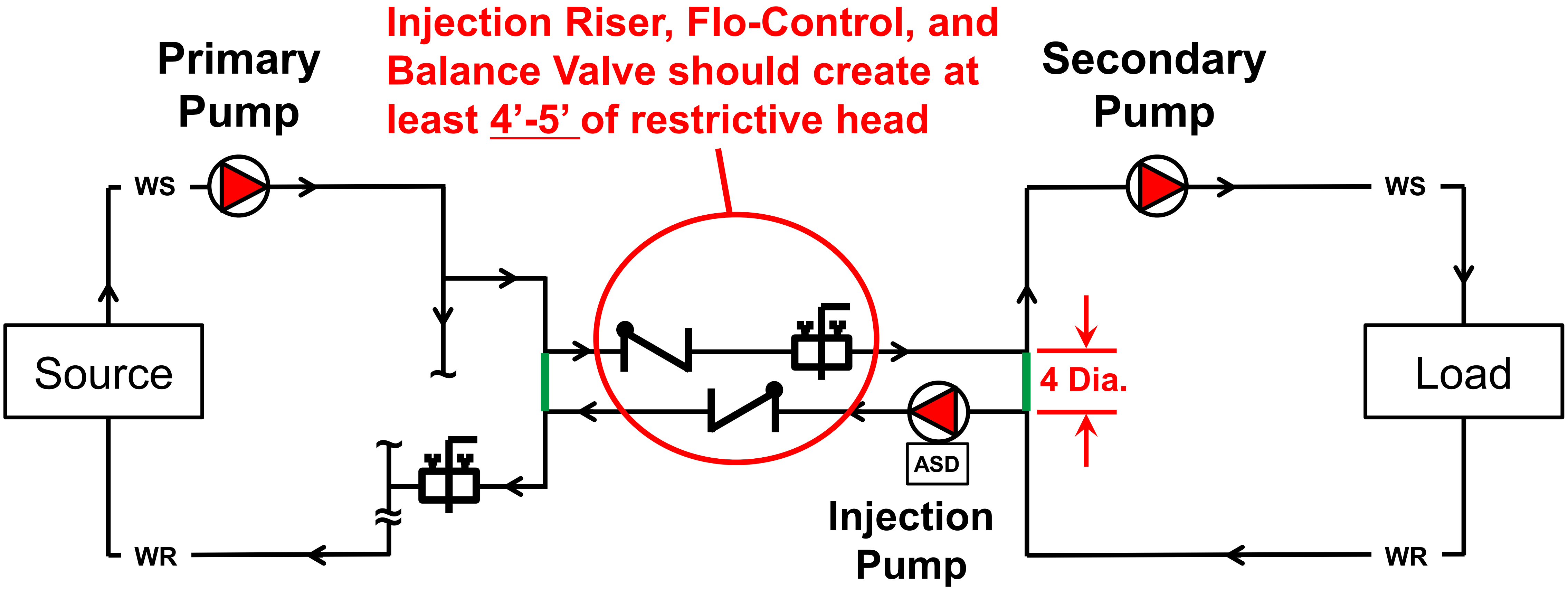
Constant Secondary Flow
(“On/Off” Constant Speed)
(Integrated Variable Speed)
Zone Pumping

Variable Secondary Flow
(Variable Speed Pump)

From a Cross-Over Bridge



From a Cross-Over Bridge



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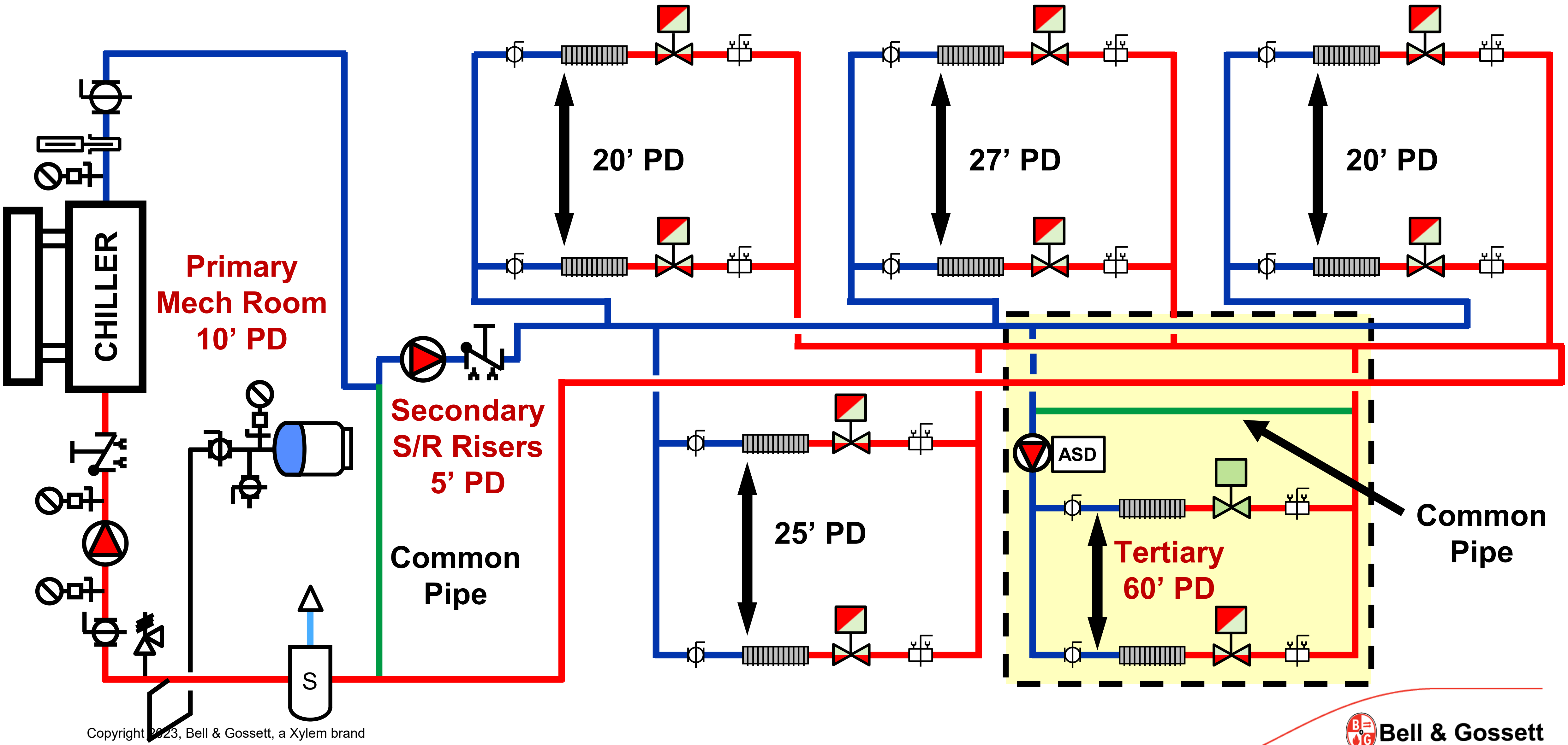
_______?



Bell & Gossett
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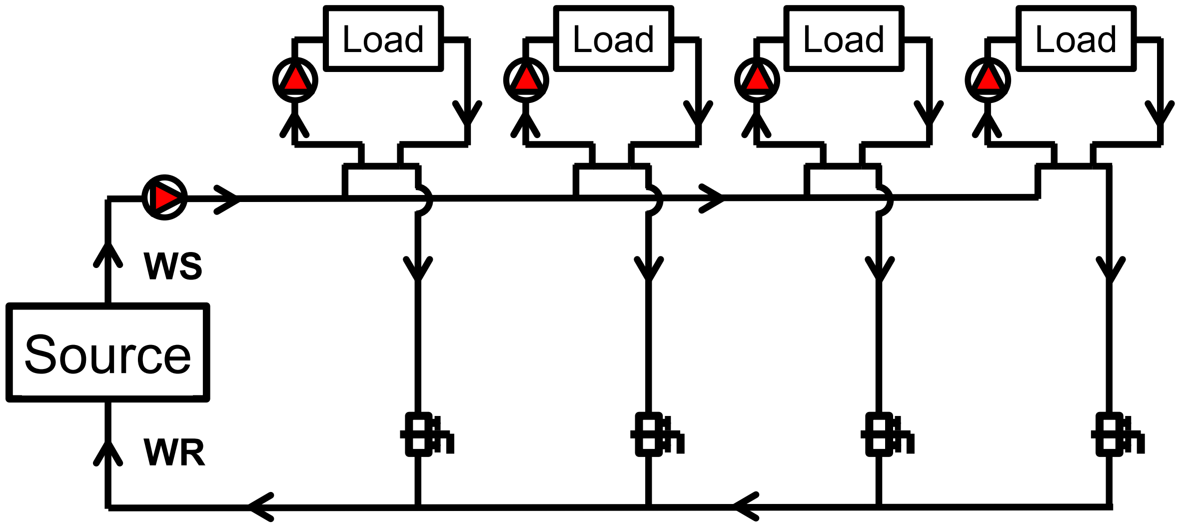
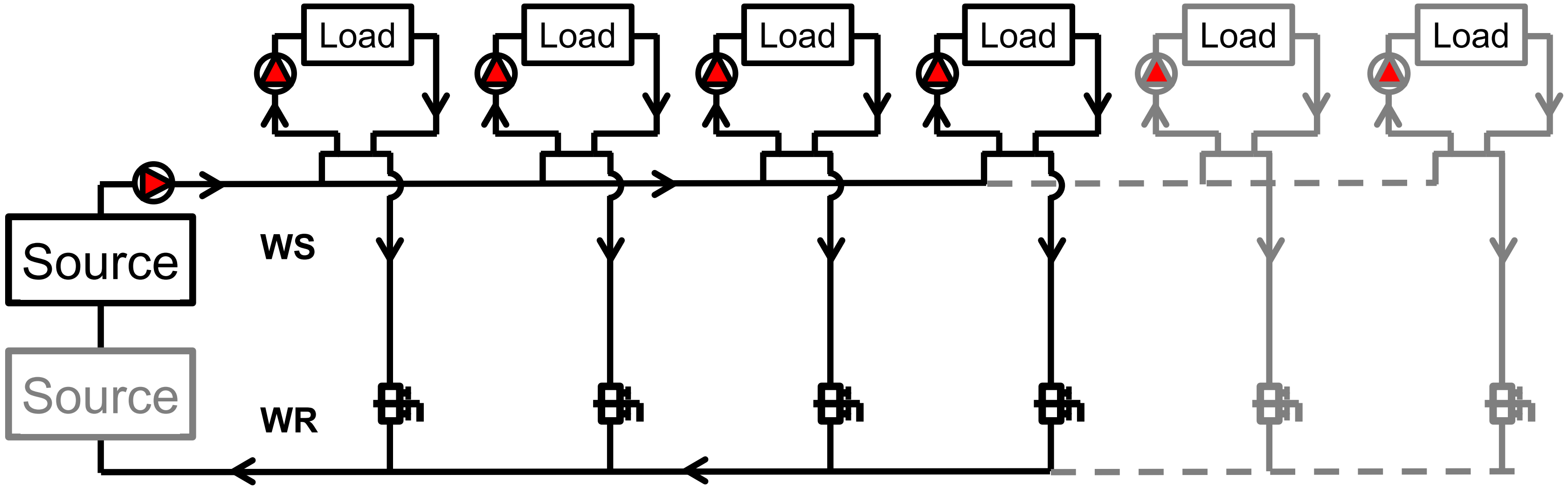
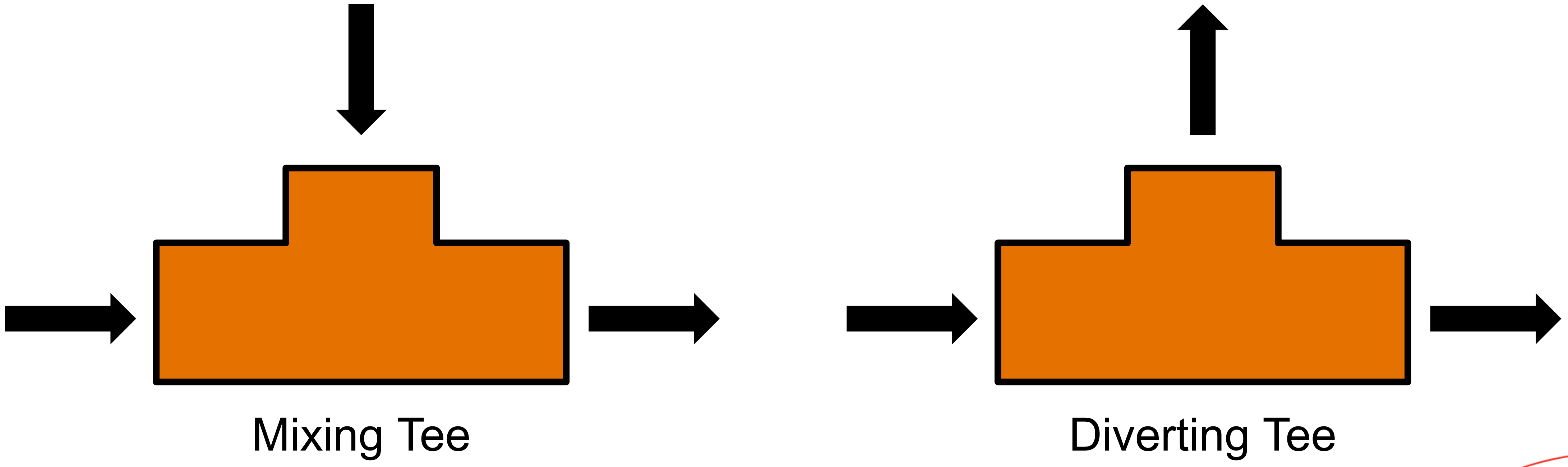

Load
Load
Load
Load
WS
Source
WR


Load
Load
Load
Load
Load
Load
Source
Source
WS
WR

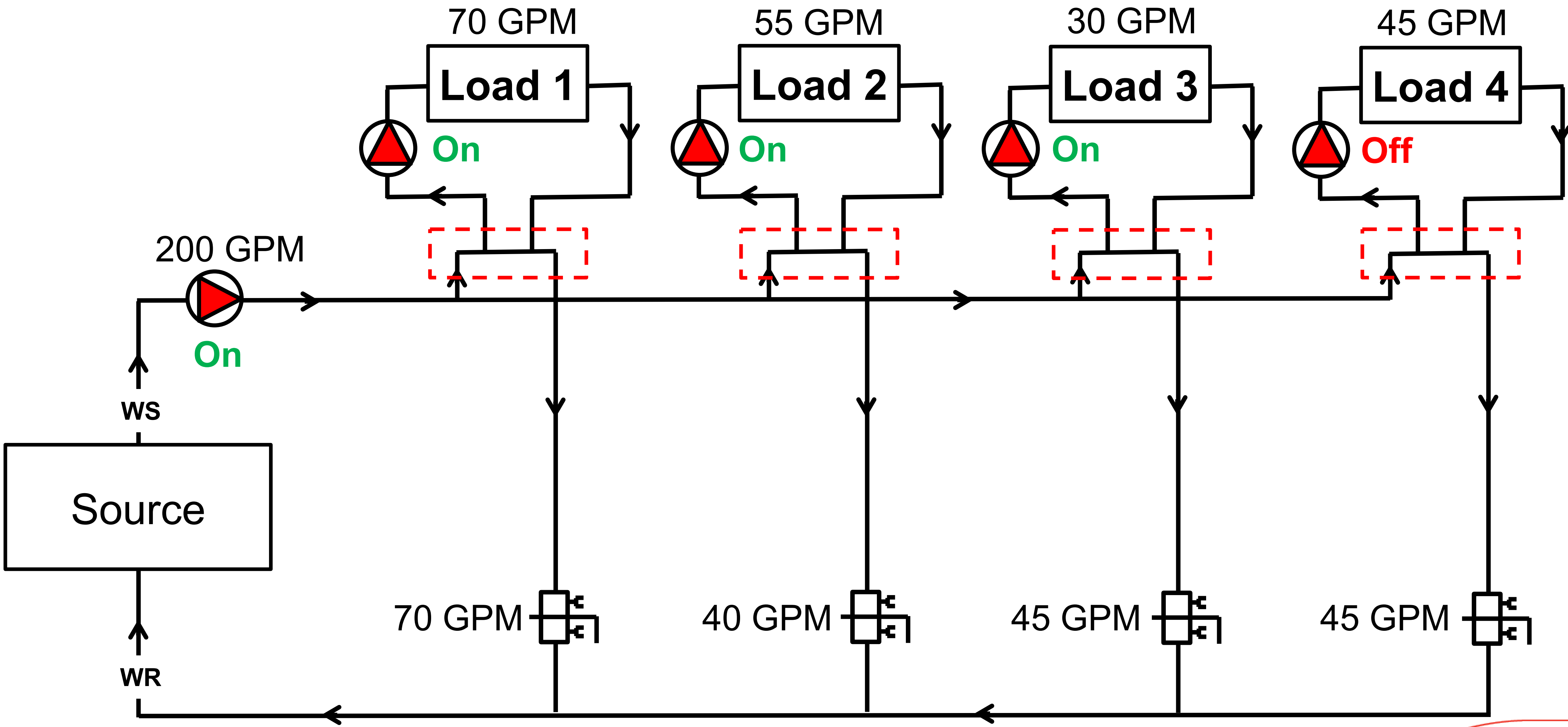
Remember – It's the Law!

The Flow Rate (GPM) Entering a Tee…..

Must Equal the Flow Rate Leaving the Tee!

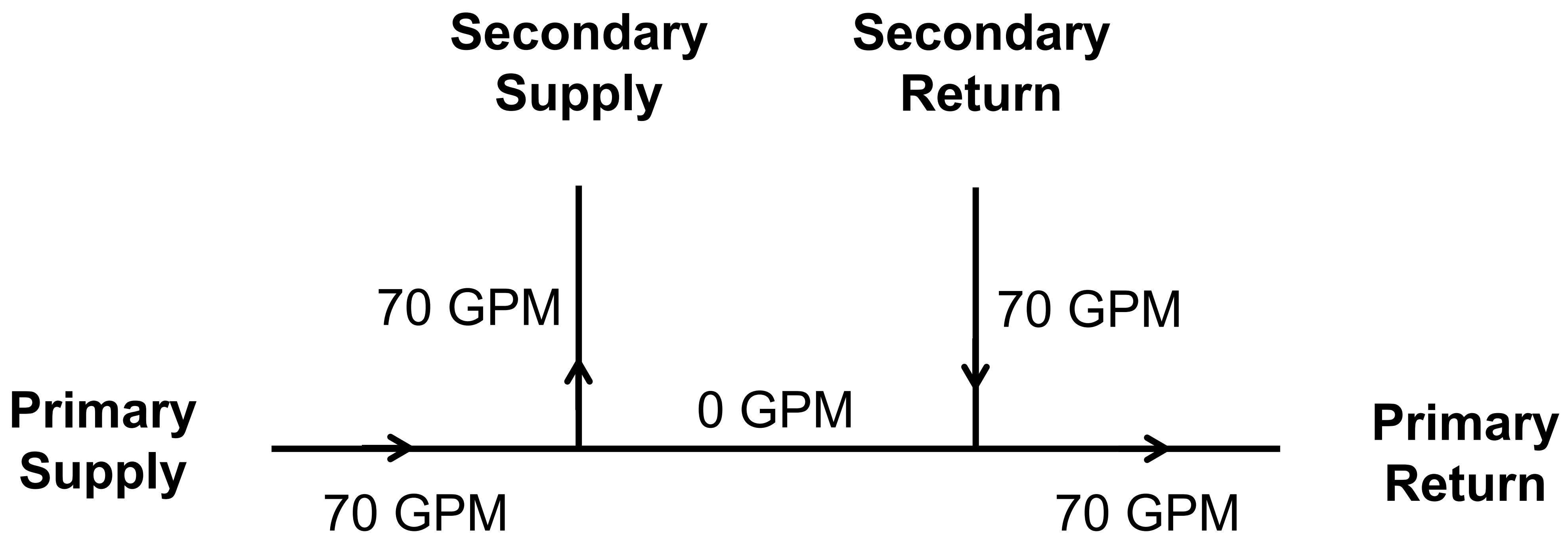


Primary-Secondary Flow Rates



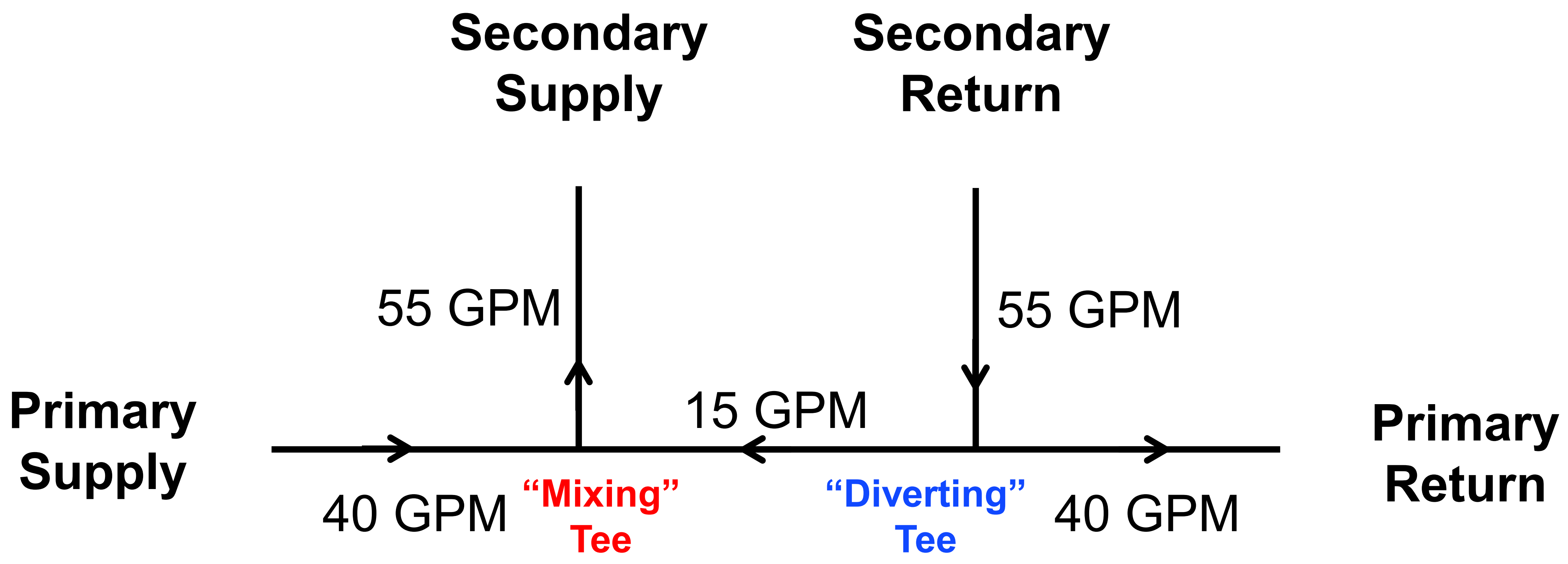
Bell & Gossett
a xylem brand

______ to Secondary Flow



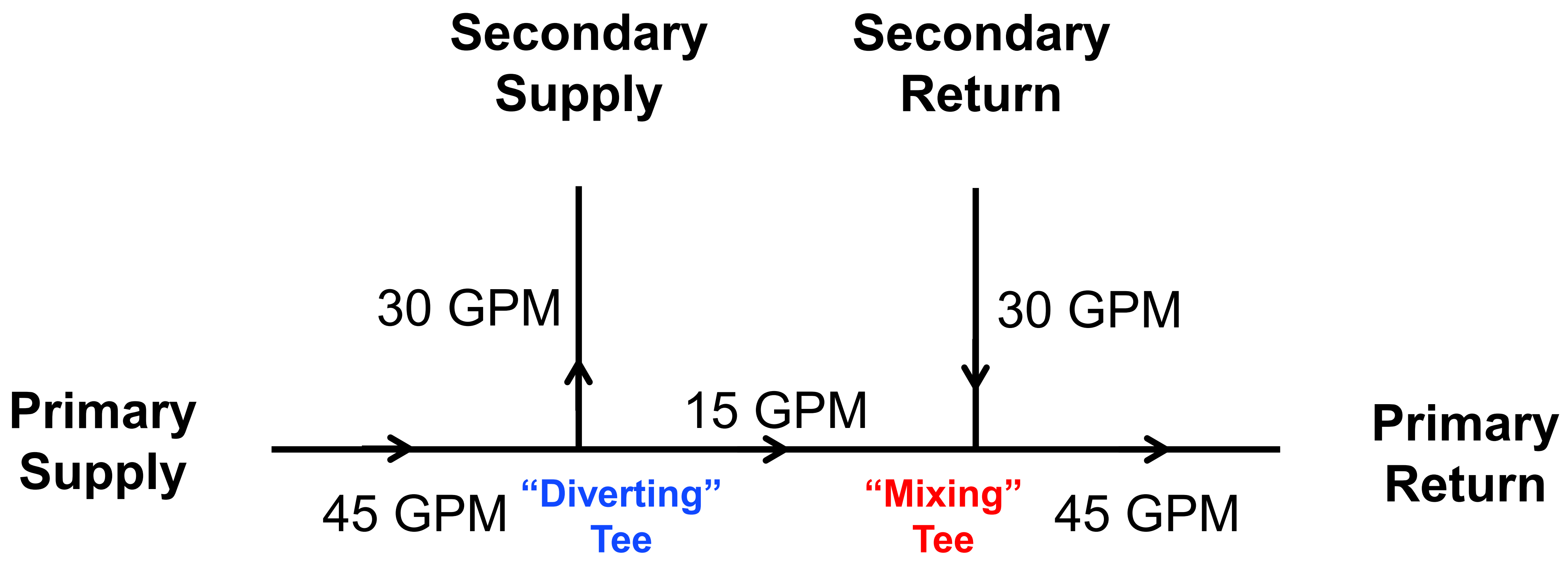
- No Flow in the Common Pipe
- Secondary Supply Temp = Primary Supply Temp
- Primary Return Temp = Secondary Return Temp

__________ Secondary Flow



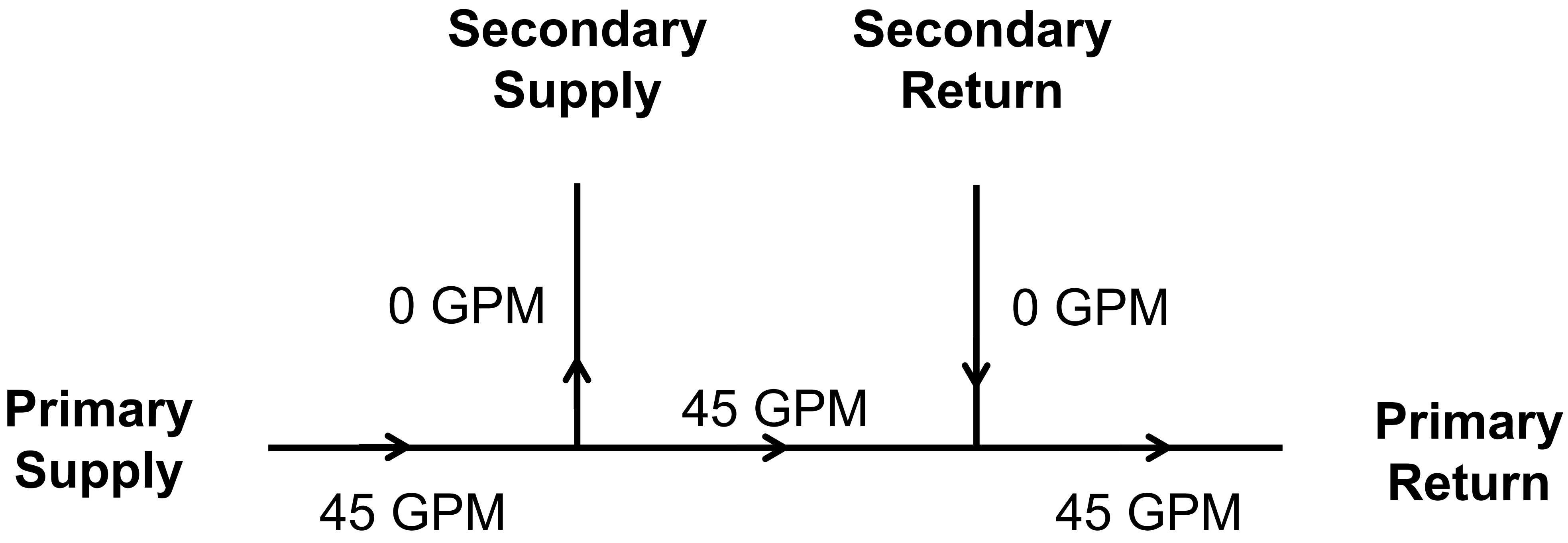
- "Reverse" Flow in the Common Pipe
- Secondary Supply Temp ≠ Primary Supply Temp **(Mixing Tee)**
- Primary Return Temp **=** Secondary Return Temp **(Diverting Tee)**

____________ Secondary Flow

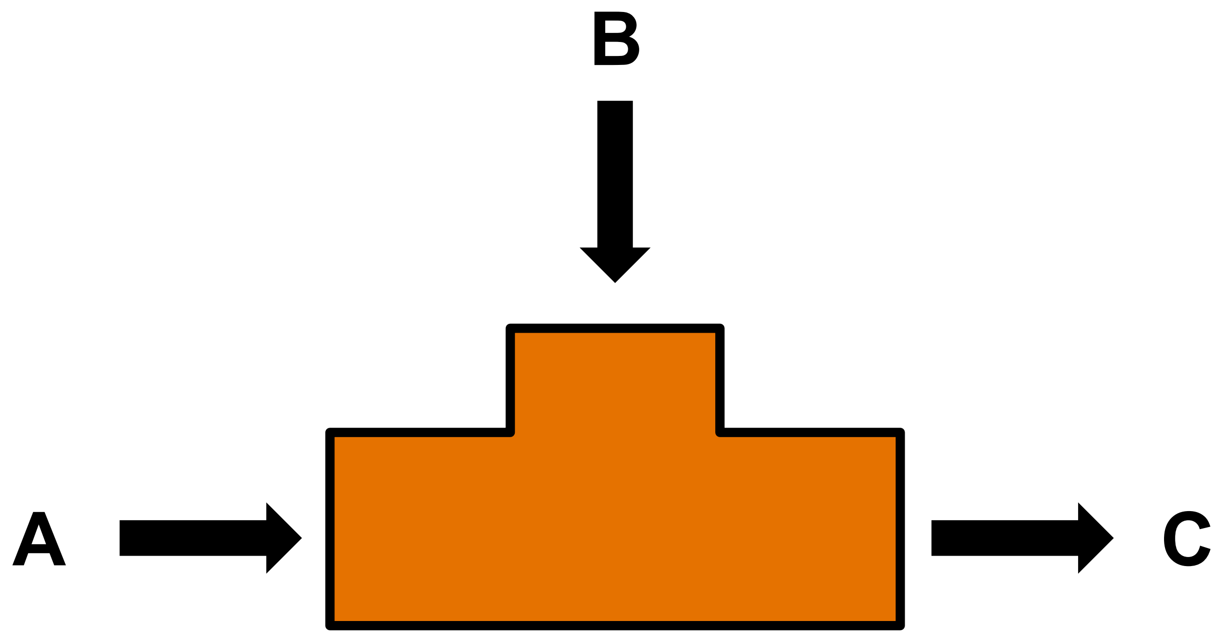


- "Forward" Flow in the Common Pipe
- Secondary Supply Temp = Primary Supply Temp **(Diverting Tee)**
- Primary Return Temp ≠ Secondary Return Temp **(Mixing Tee)**

___ Secondary Flow



- “Forward” Flow in the Common Pipe
- No Secondary Flow
- Primary Return Temp = Primary Supply Temp



Mixing Tee

$$(Flow_C \times Temp_C) = (Flow_A \times Temp_A) + (Flow_B \times Temp_B)$$

$$Temp_C = \frac{(Flow_A \times Temp_A) + (Flow_B \times Temp_B)}{Flow_C}$$

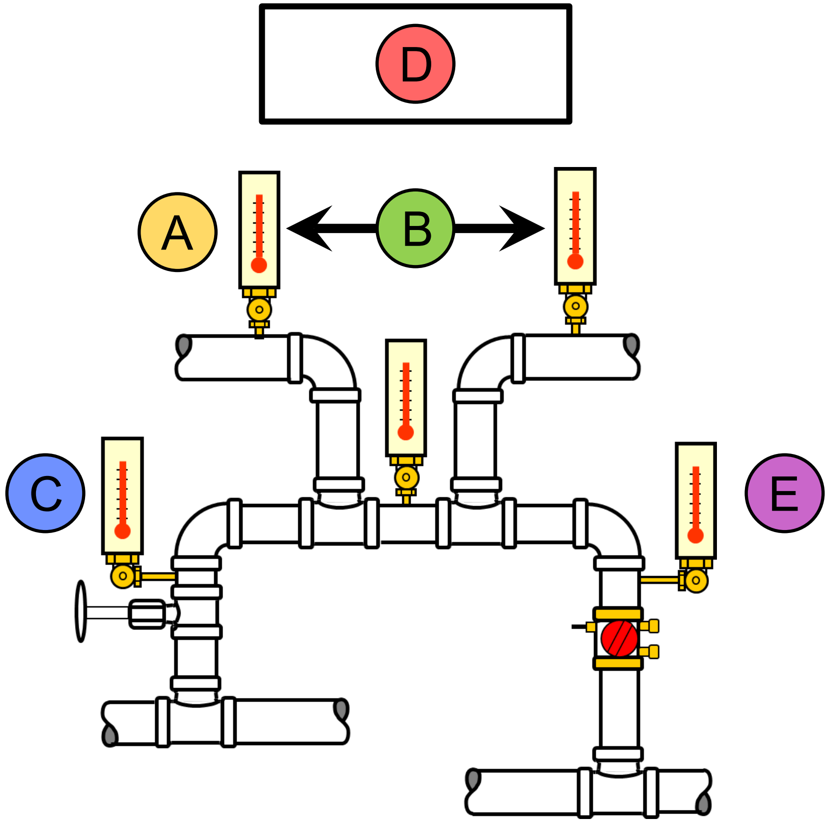
A. What is required supply water temperature to secondary load?

B. What is the design ΔT across secondary load?

C. What is the primary supply water temperature?

D. What is the total Btu/hr required for the secondary?

E. What is the primary return temperature?



Example: A secondary load of 300,000 Btu/hr requires 55°F supply water and is designed for a 15°F ΔT. The primary supply water from the chiller is 45°F.

What is the required cross-over bridge flowrate?

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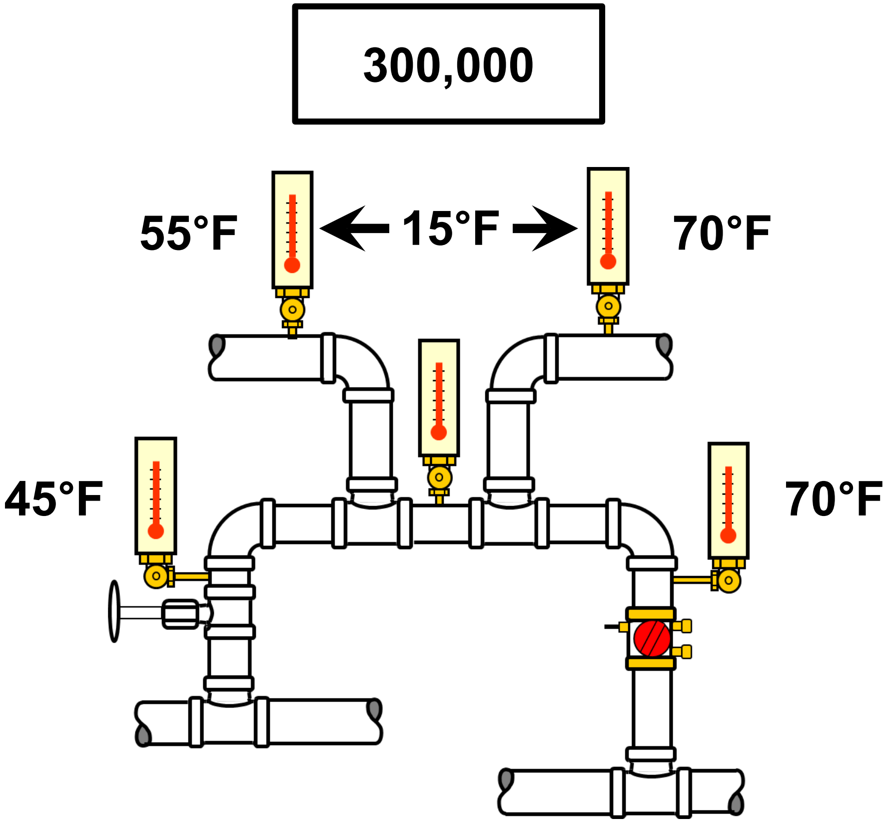

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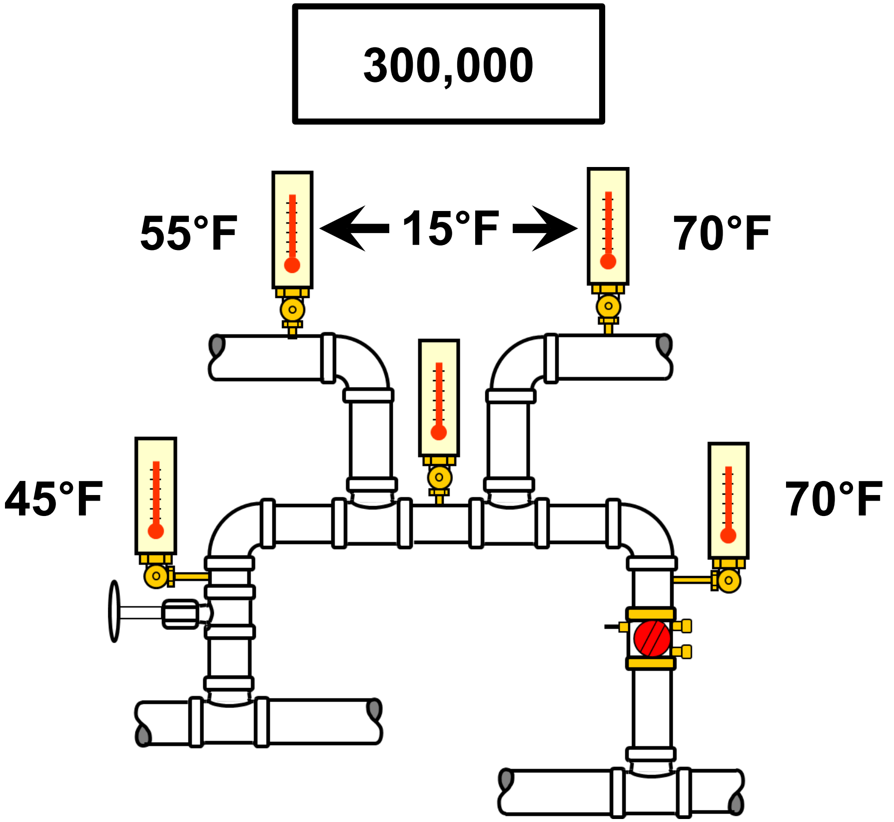

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70°F - 45°F = 25°F ΔT across the bridge

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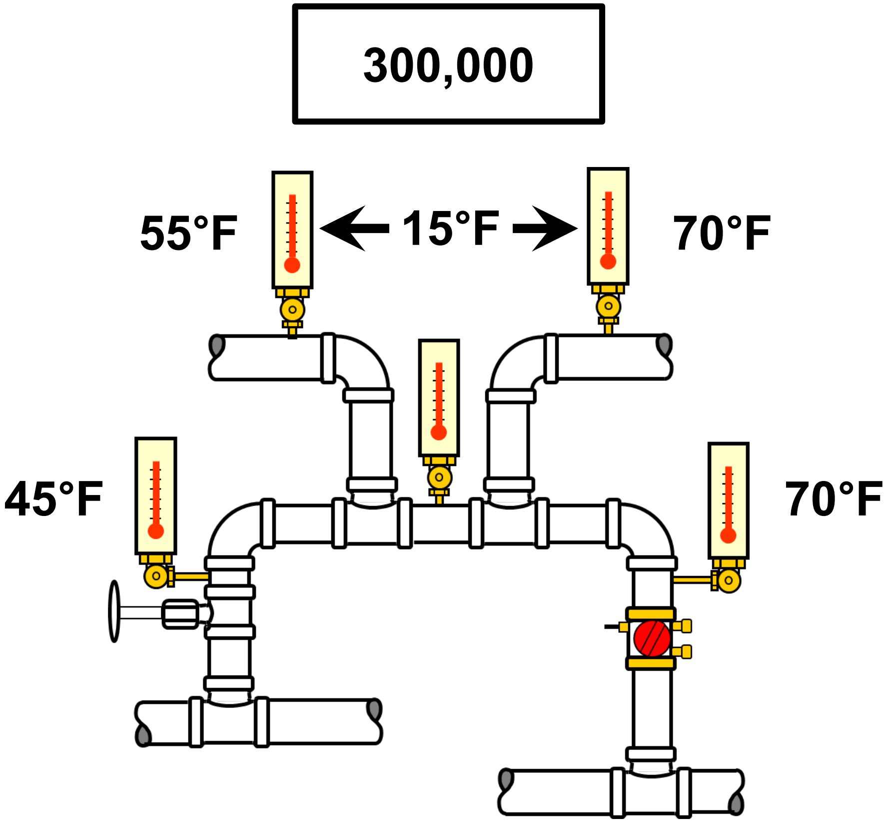

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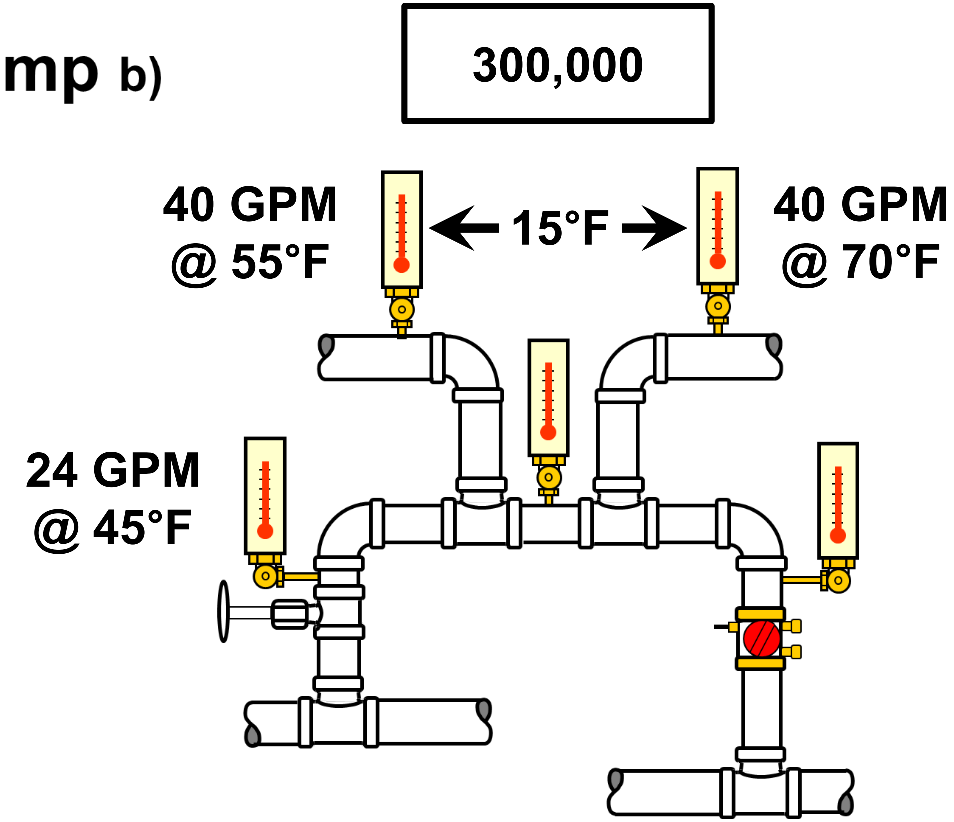
$$\frac{\text{Btu/Hr}}{500 \times \Delta T} = \text{GPM} \qquad \frac{300{,}000}{500 \times 25} = \textbf{24 GPM bridge supply from main}$$

$$\frac{300{,}000}{500 \times 15} = \mathbf{40\ GPM}$$

Flow c x Temp c = (Flow a x Temp a) + (Flow b x Temp b)



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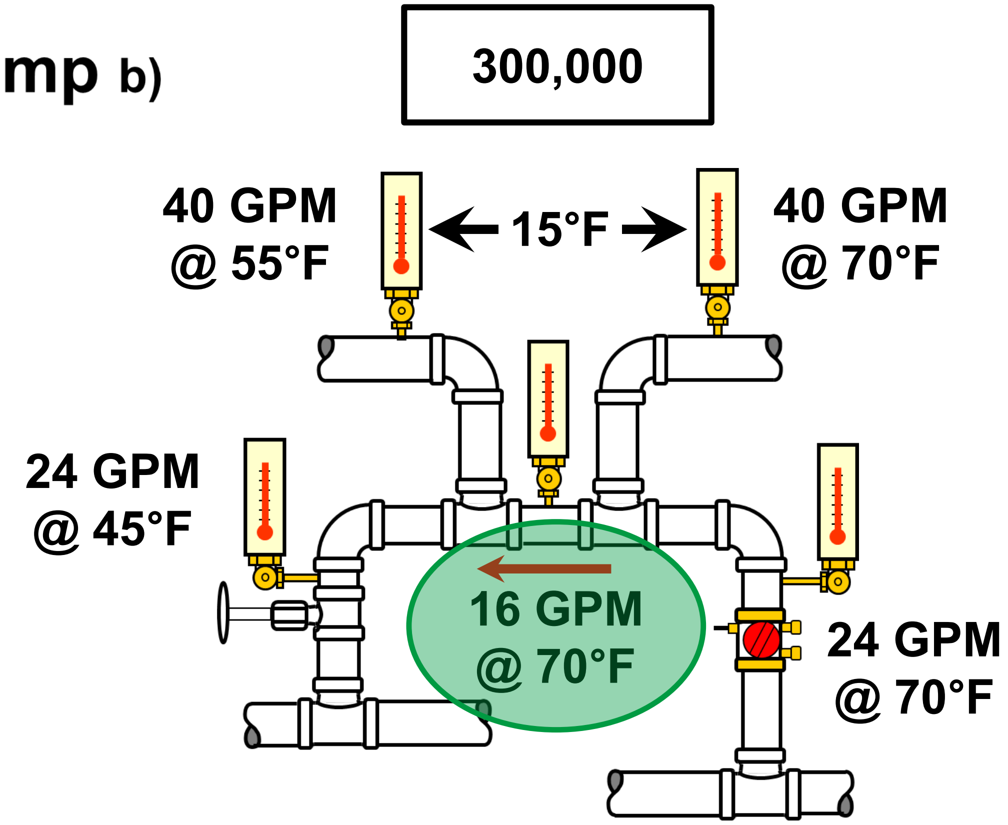
$$\frac{300{,}000}{500 \times 15} = \mathbf{40\ GPM}$$

Flow c x Temp c = (Flow a x Temp a) + (Flow b x Temp b)

40 x 55 = (24 x 45) + (16 x 70)

2200 = (1080) + (1120)

2200 = 2200



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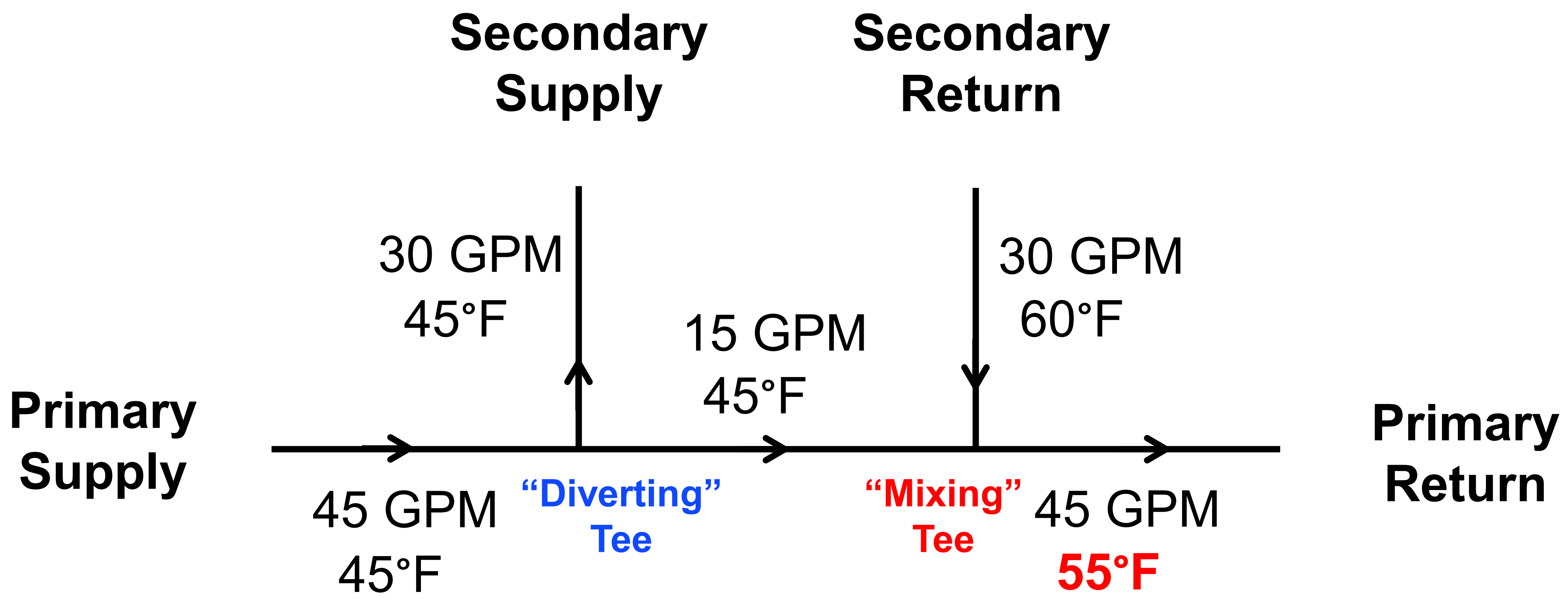
______________ Secondary Flow



$$\text{Temp}_C = \frac{(15 \times 45) + (30 \times 60)}{45} = 55.0°F$$

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Typical Applications

- Large, diverse systems with high cumulative pressure drops
- Different Supply Water Temperatures in zones
- Stabilization of Boiler and Chiller flows required
- Freeze protection for Air Handling Coils

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Benefits

- Design “large” primary loop temperature drops *(Smaller pump and piping)*
- Offers flexibility of Constant or Variable Speed Primary Pump operation
- Can reduce overall system pumping energy