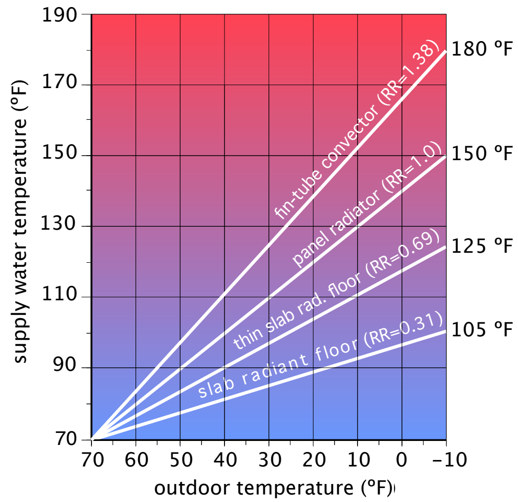
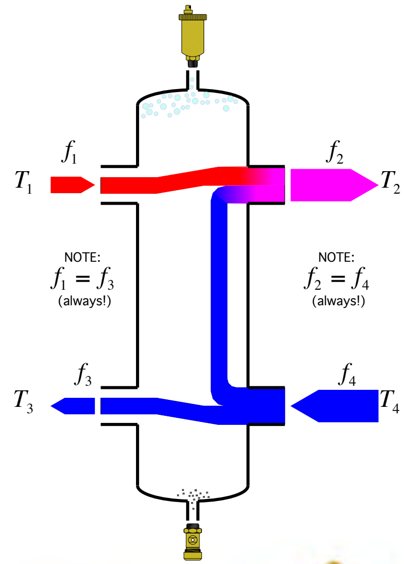
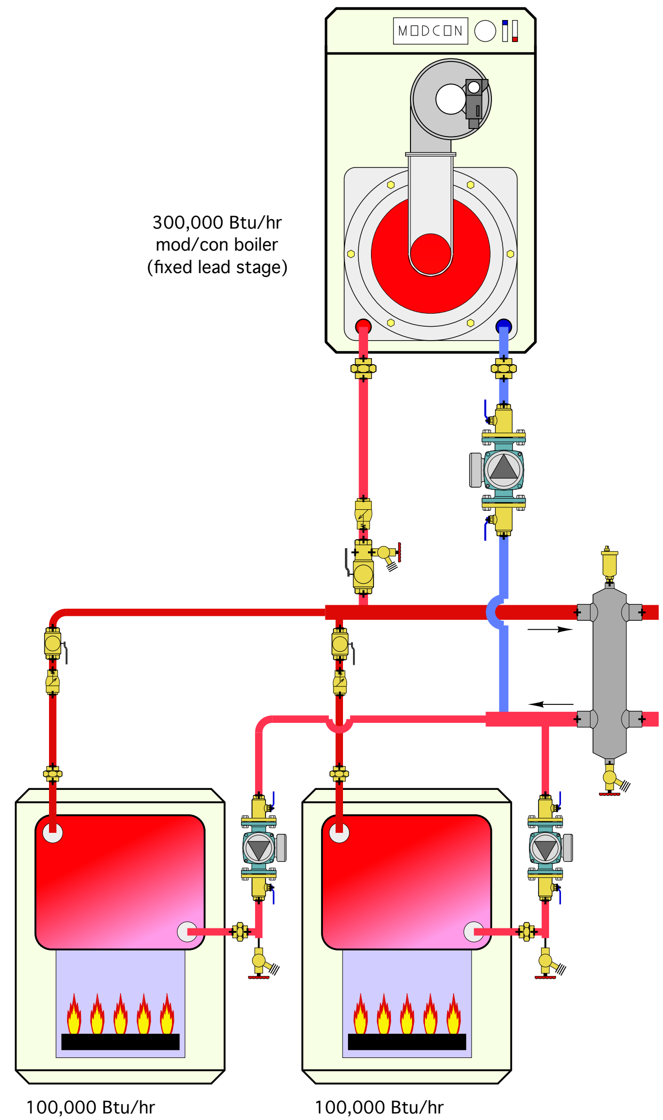
"Best Practices in Modern Hydronic Heating - THE DETAILS

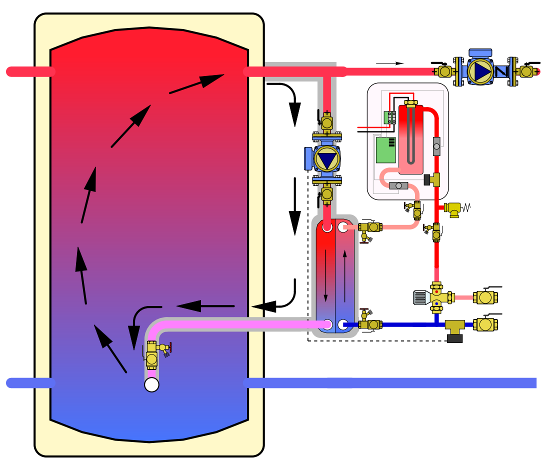






ENERGY DESIGN conference & expo

2014



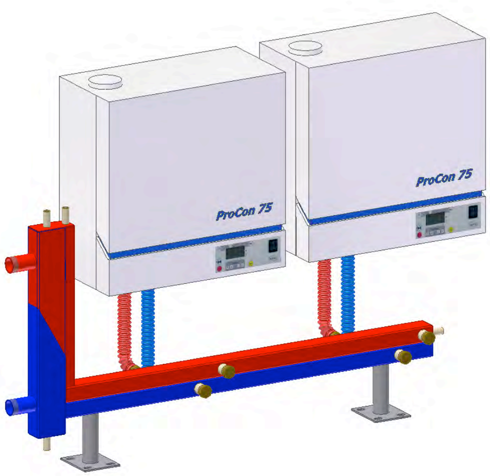
presented by:

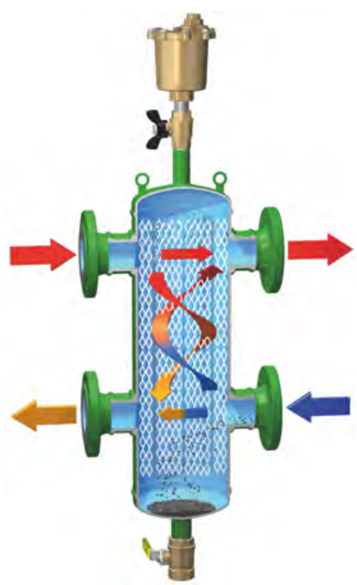
John Siegenthaler, P.E.
Appropriate Designs
Holland Patent, NY
www.hydronicpros.com

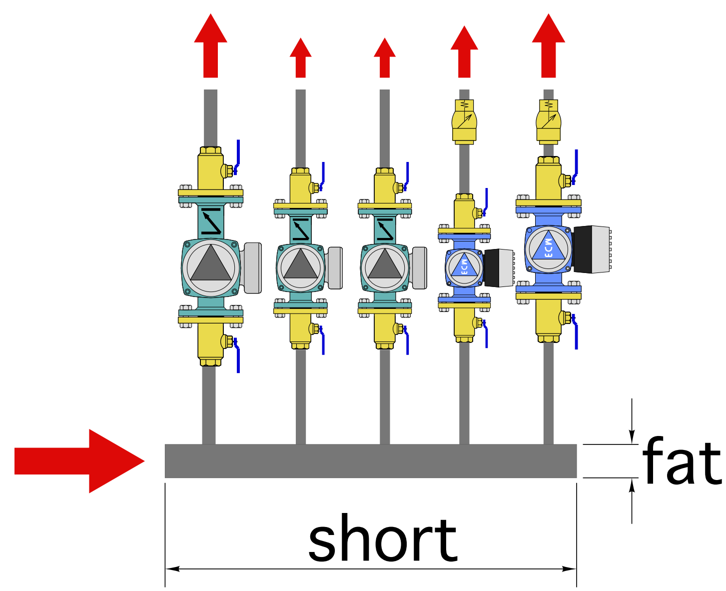
"Best Practices in Modern Hydronic Heating - AN OVERVIEW

This Afternoon's topics...

- Multiple mod/con boiler systems
- Hydraulic separation
- Distribution efficiency
- Applying high efficiency circulators
- Outdoor reset control
- Hydronic approaches to on-demand domestic water heating





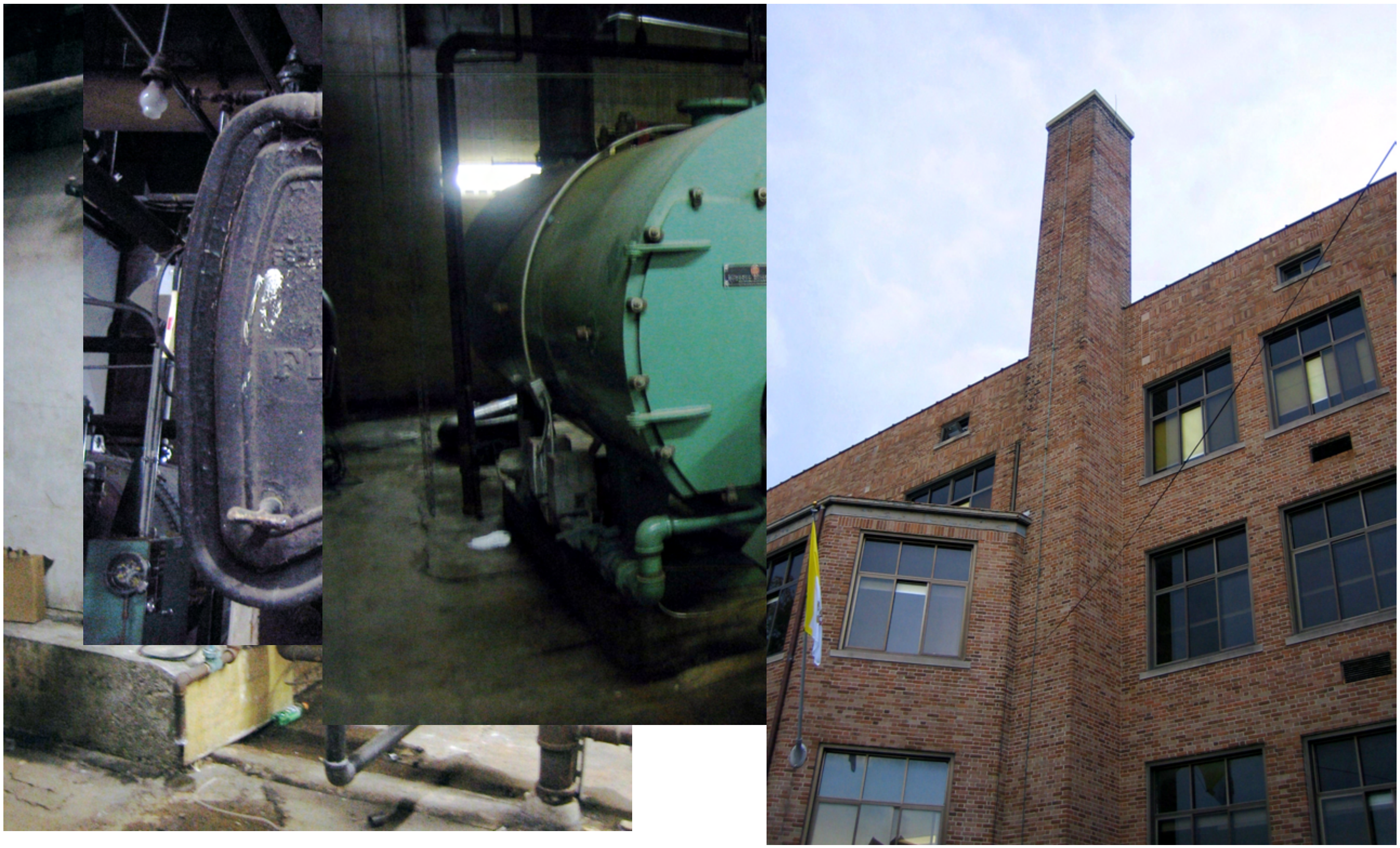


Multiple modulating / condensing boilers

The <u>new normal</u> in commercial boiler systems

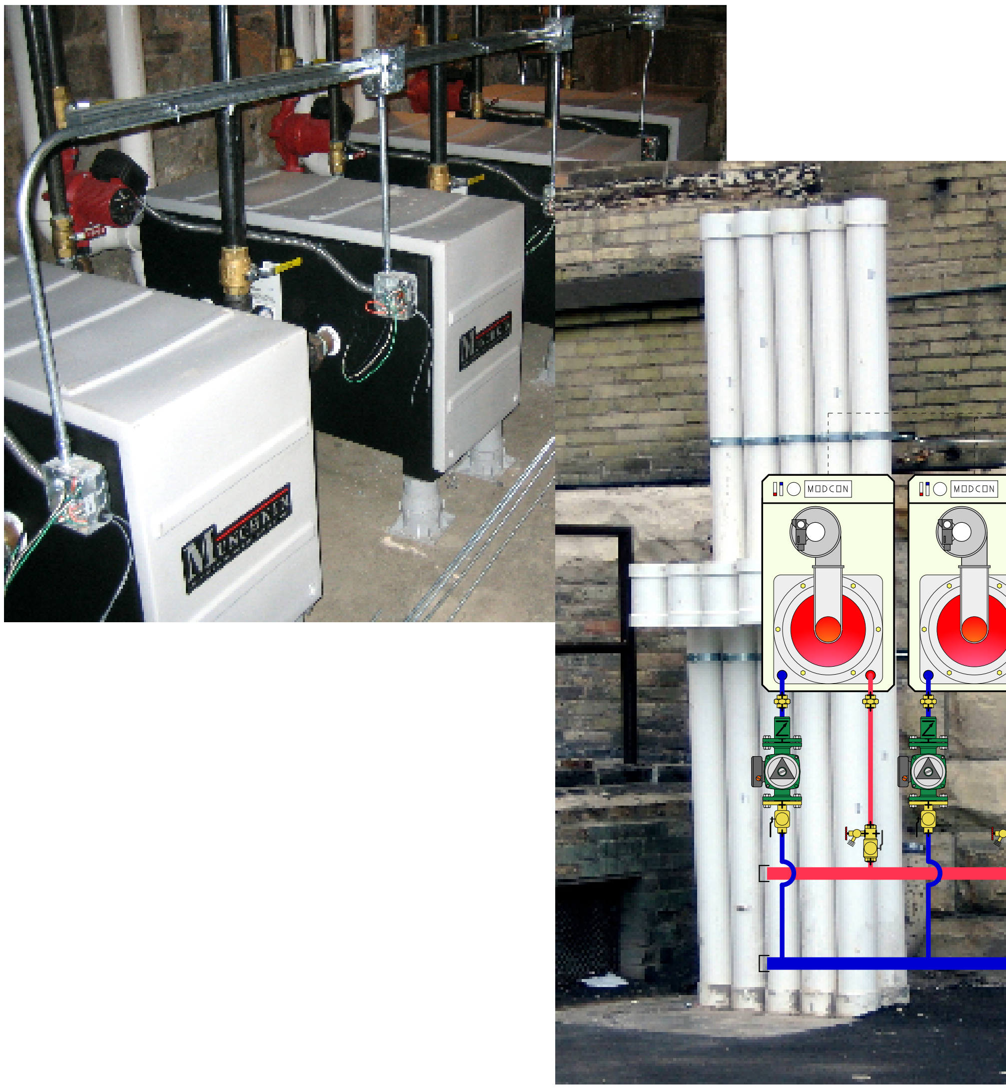
Multiple modulating / condensing boilers

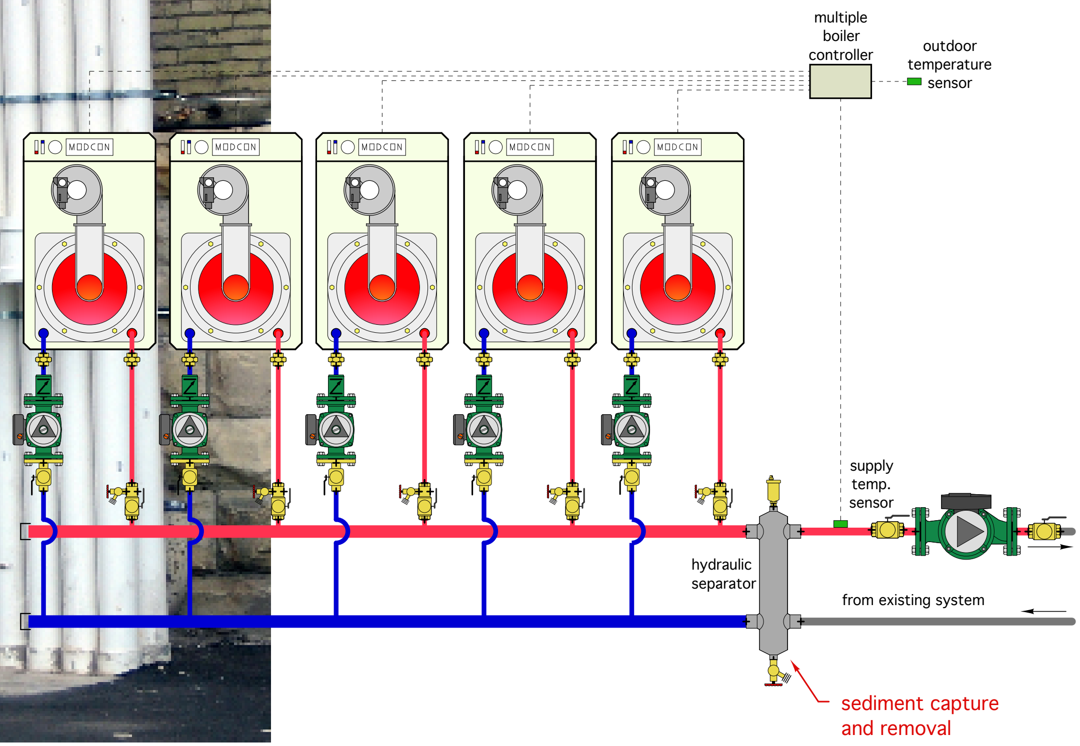
The evolution of an old hydronic system



Multiple modulating / condensing boilers

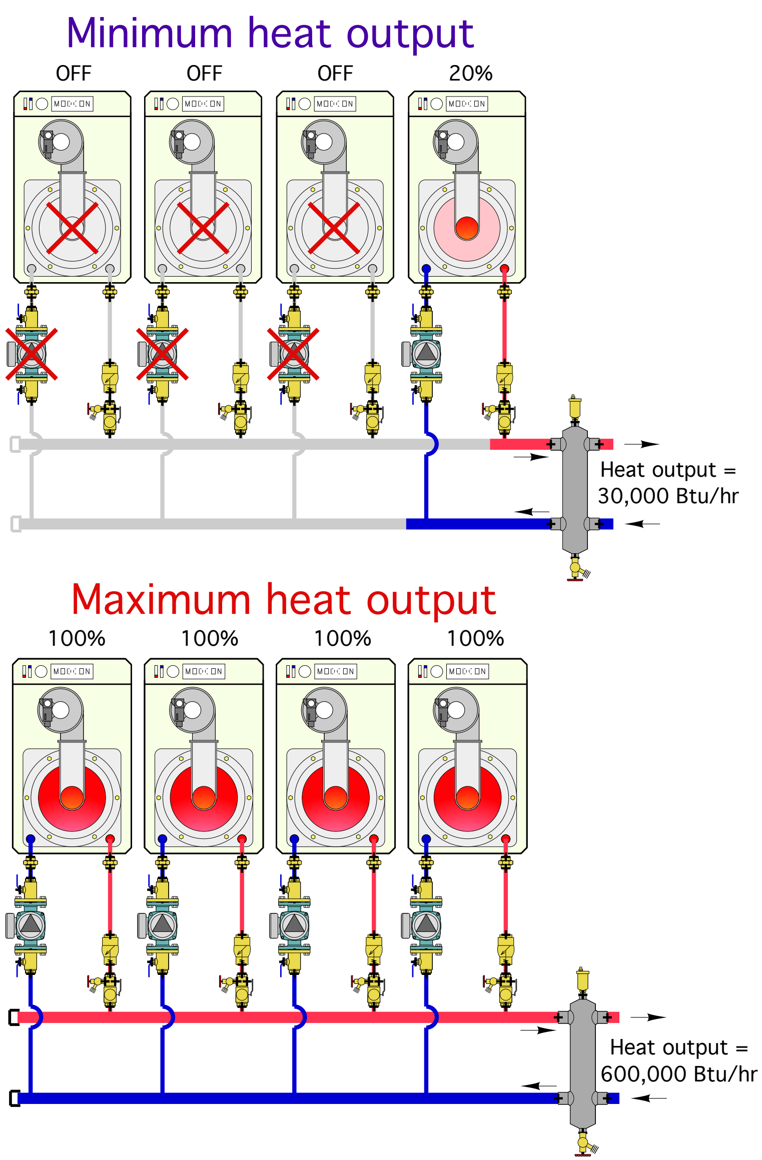
The evolution of an old hydronic system

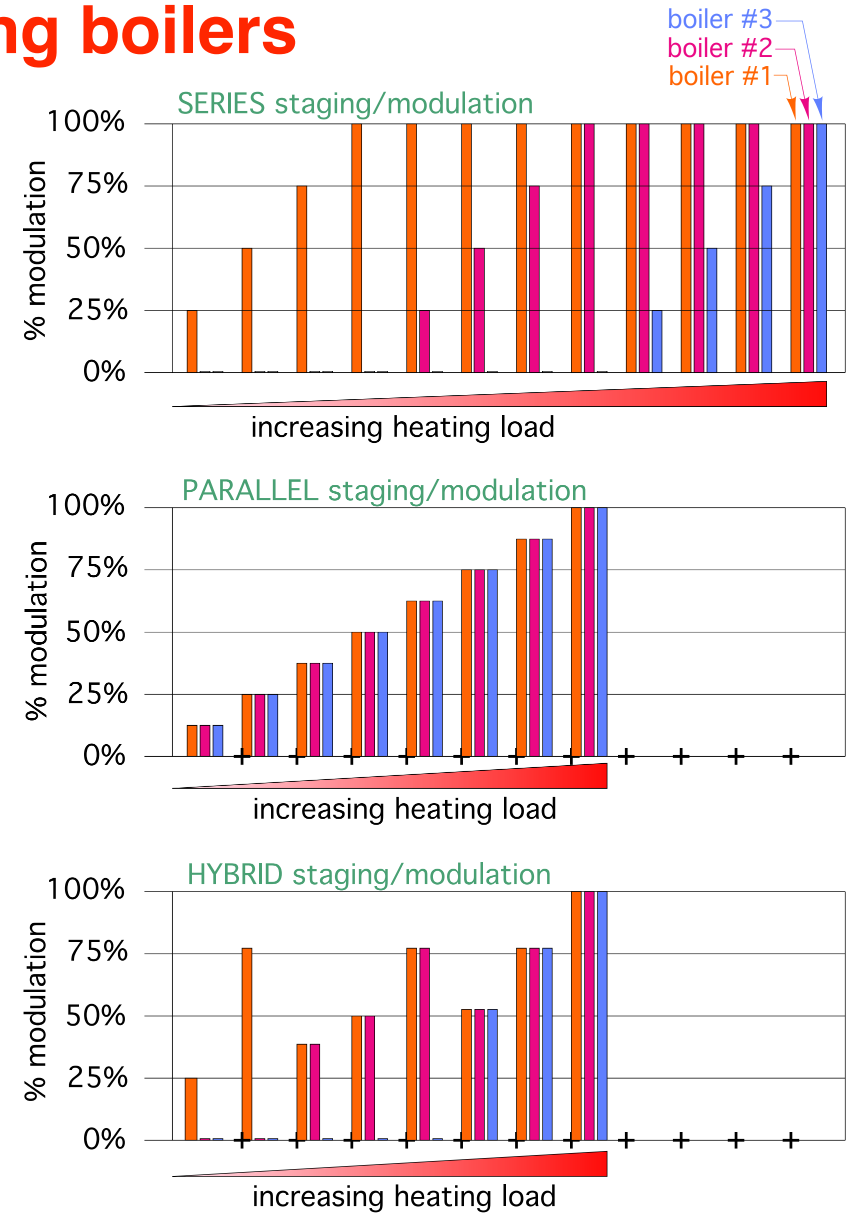




Multiple modulating / condensing boilers

Multiple modulating / condensing boilers, combining staging and modulation

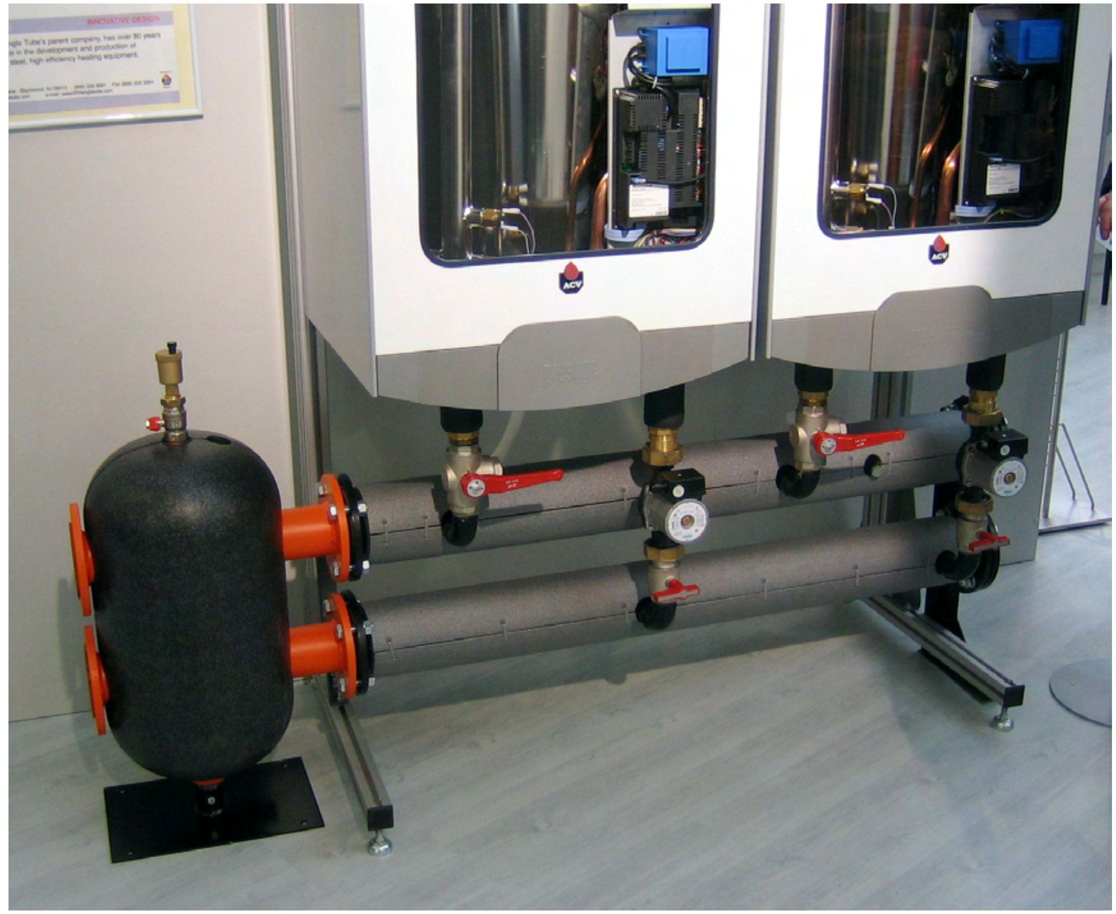




system turndown ratio = $\frac{600{,}000 \text{ Btu/hr}}{30{,}000 \text{ Btu/hr}}$ = 20/1

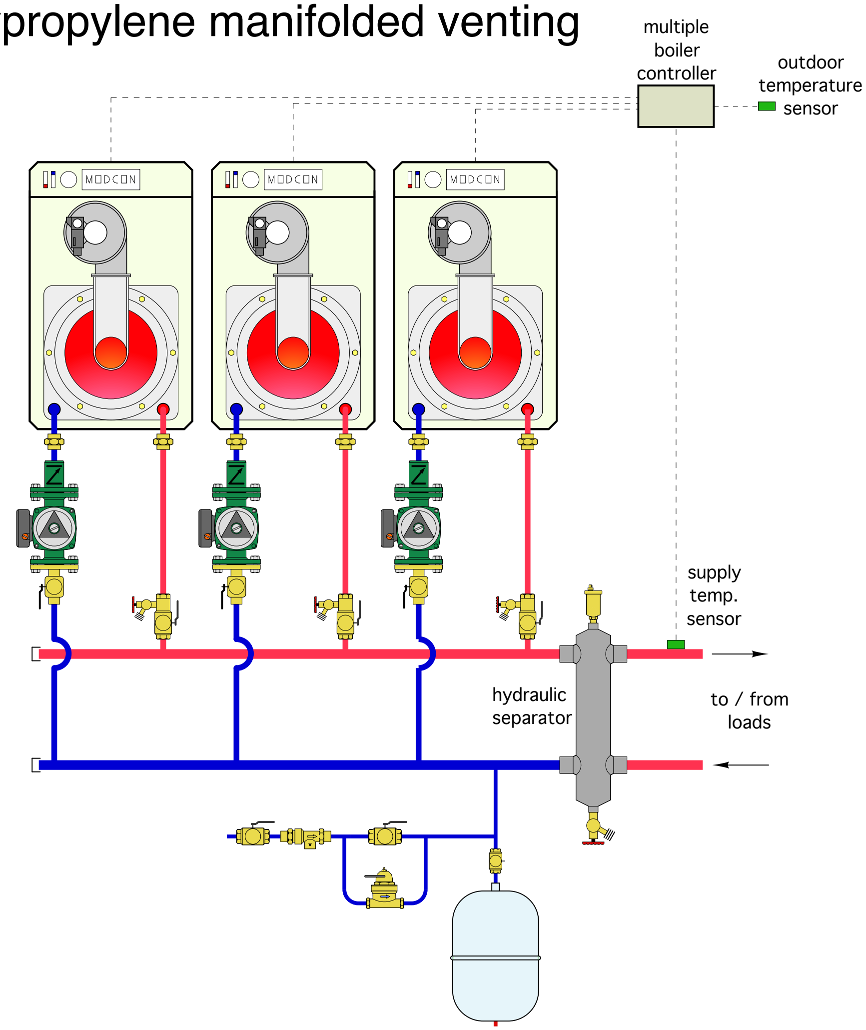
Multiple modulating / condensing boilers

Typical European concepts for multiple mod/con installation:



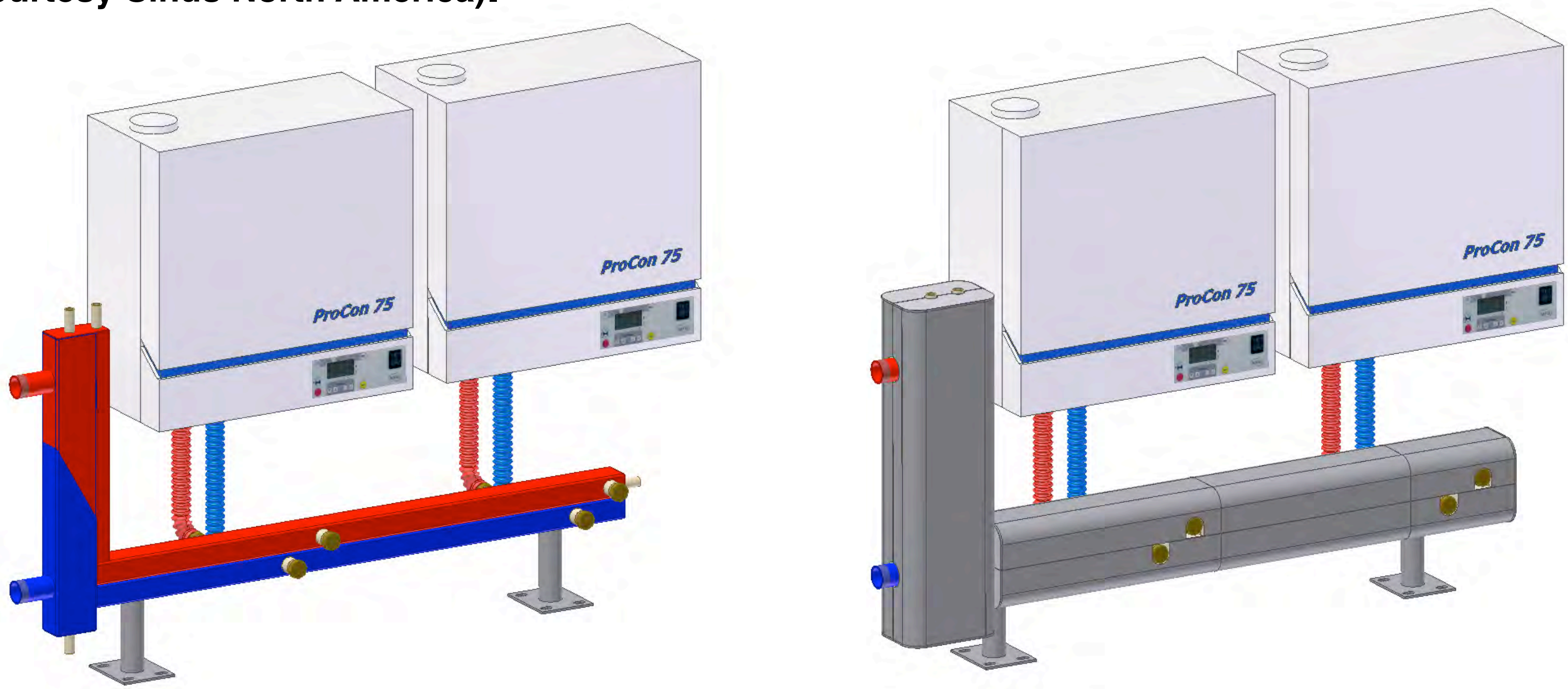
What did you notice in common on those last two photos?

- Modular manifold system - could be expanded if necessary
- Hydraulic separator interface to system
- Pre-engineered racking systems
- individual circulators on each boiler
- Polypropylene manifolded venting



Boiler manifold with integral hydraulic separator

(courtesy Sinus North America).



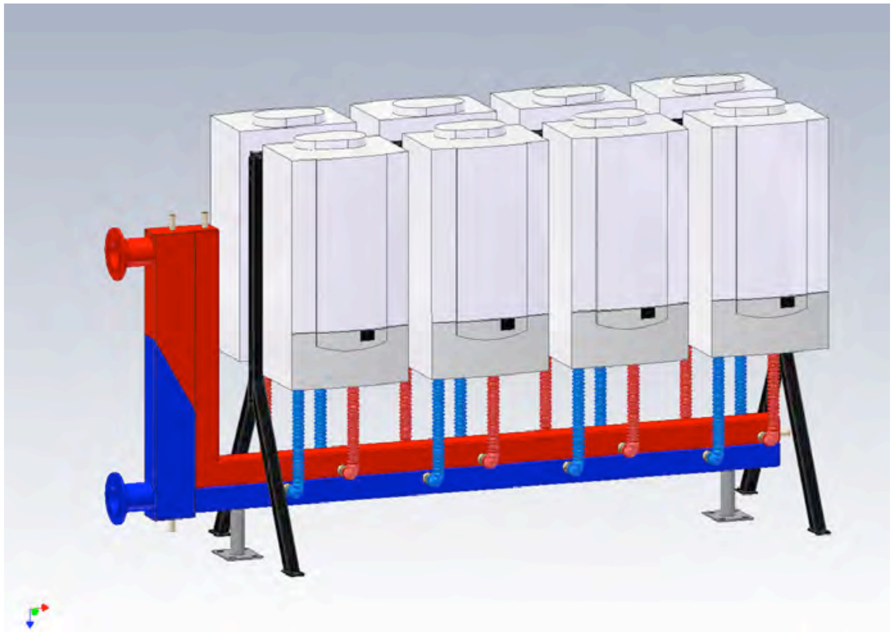
Form fitting insulation is supplied with all manifolds.

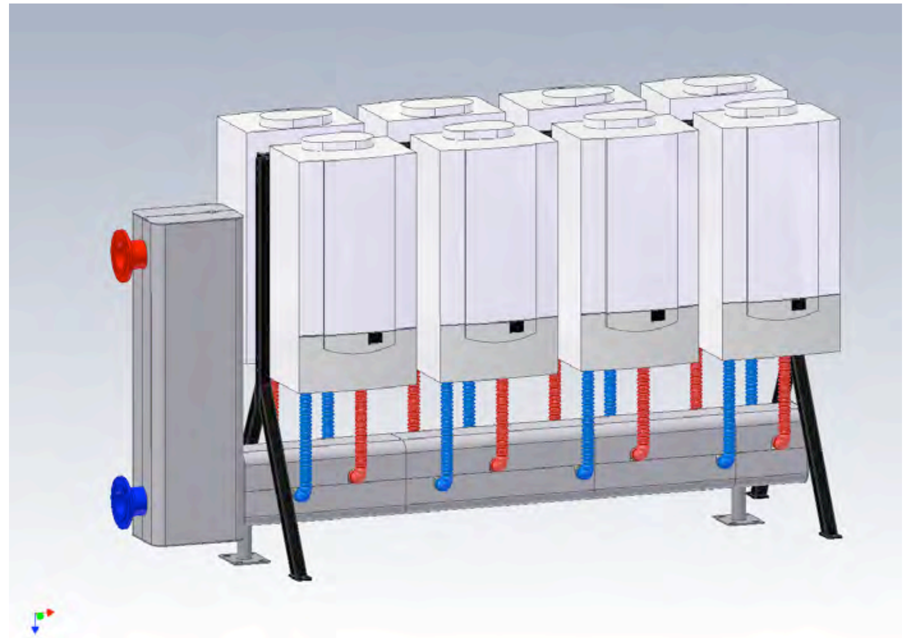
Flexible piping connects each boiler to low manifold. (Boilers have integral circulators and check valves.)

Notice that two additional boilers can be added to the front side of lower manifold.

Here's what the real products look like…

How about 8 mod/cons with integral hydraulic separator…
(courtesy Sinus North America).





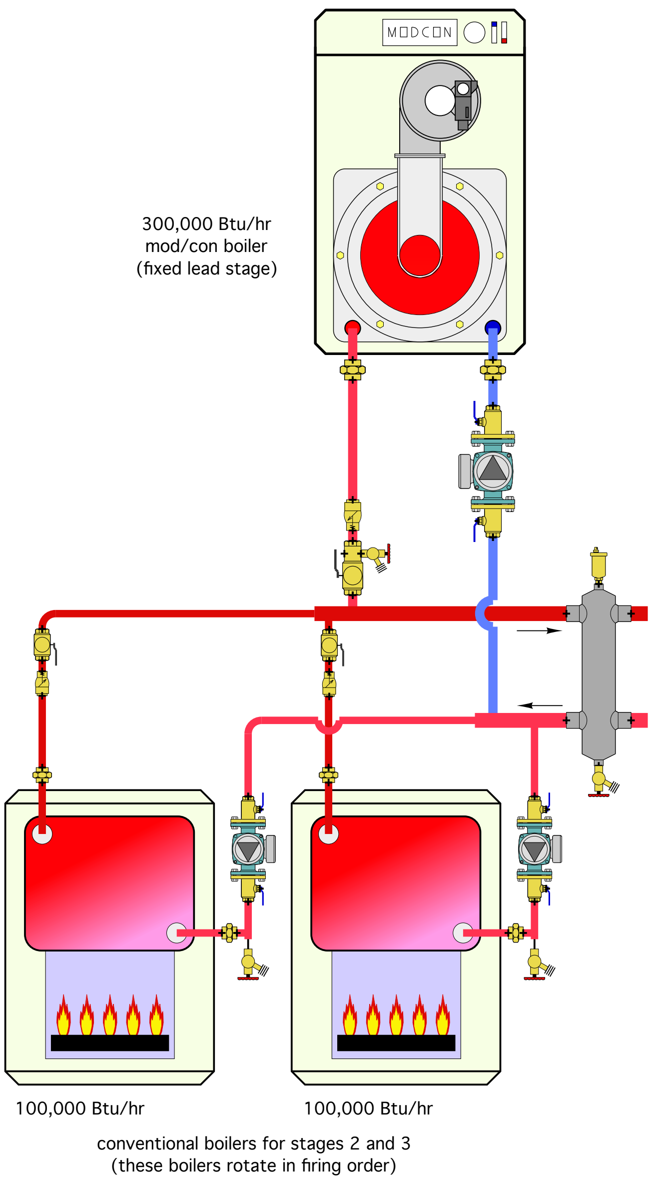
Think of the output per unit of mechanical room floor area…

Each boiler can be independently serviced .

Flexible piping connects each boiler to low manifold. (Boilers have integral circulators and check valves.)

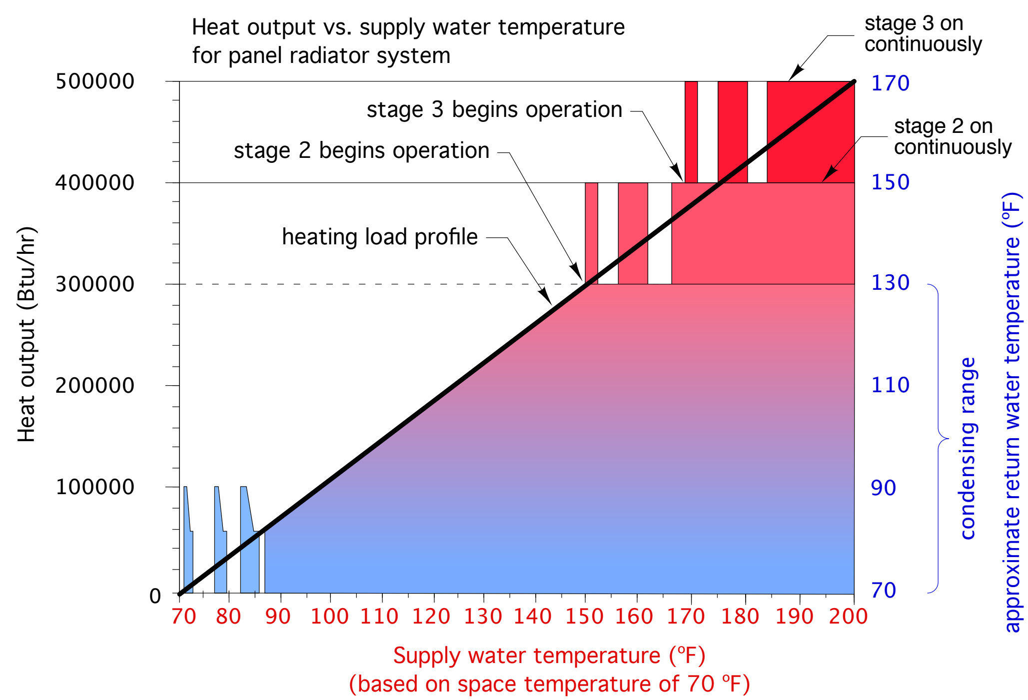
High efficiency gas-fired boilers

hybrid multiple boiler systems



Condensing boiler operates during "baseload" conditions when water temperatures are lowest.

Conventional boilers are staged on when needed, and after water temperatures are above condensing mode operation



Multiple mod/con boilers for high capacity domestic water heating…

14 simultaneously operating showerheads + whirlpool tub = 1 master bathroom

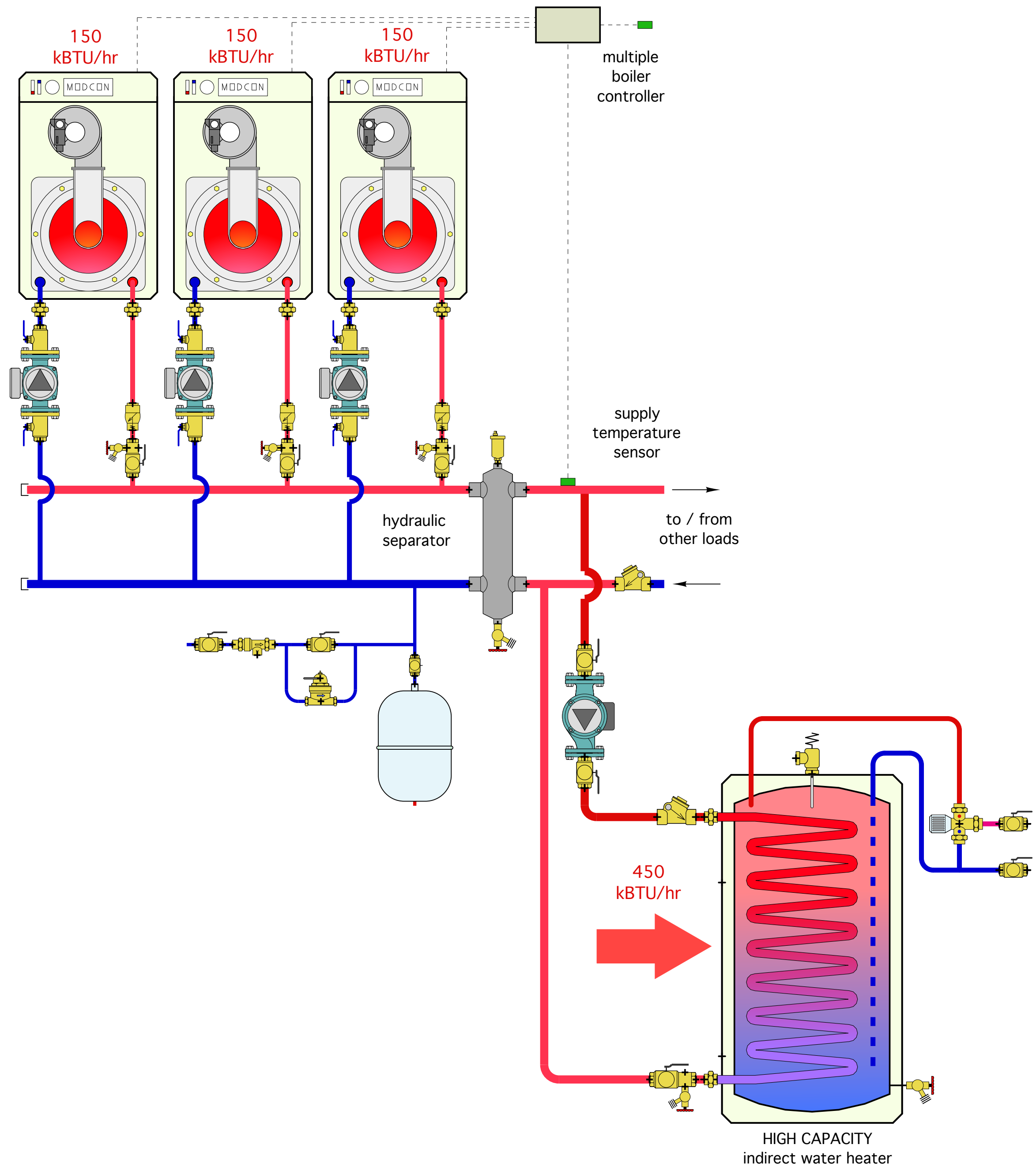
Do you suppose this is the only bathroom in this house?

Multiple mod/con boilers for high capacity domestic water heating…

This approach could supply 450,000 Btu/hr to sustain a 15 gallon per minute load at 110 °F delivery temp. *indefinitely,* even without considering the hot water reserve in tank.

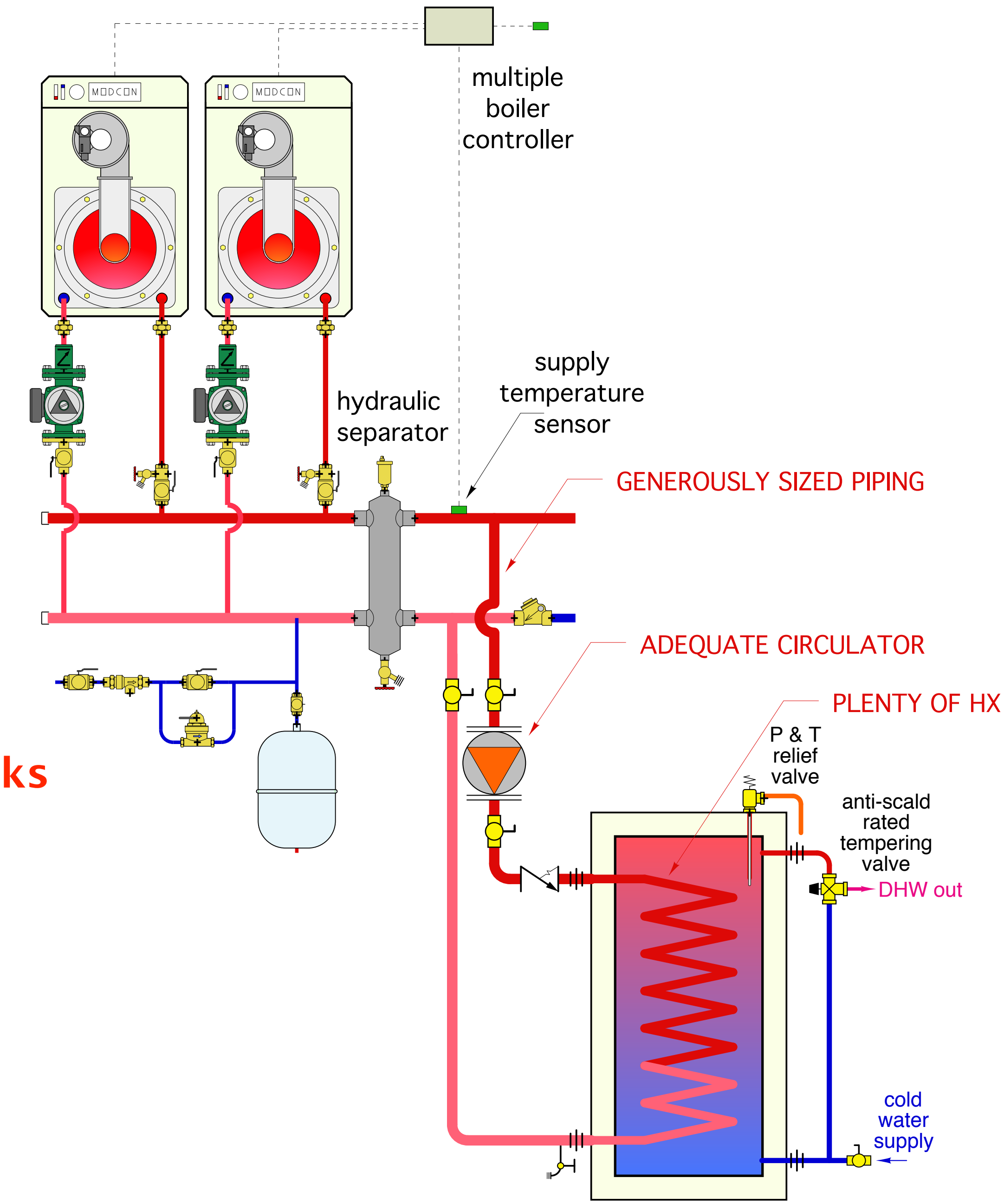
At other times, the multiple-mod/con boiler system can reduce to 5-10% of full capacity for space heating while still maintaining high efficiency.

Much better than a single large boiler serving both DHW and space heating loads.



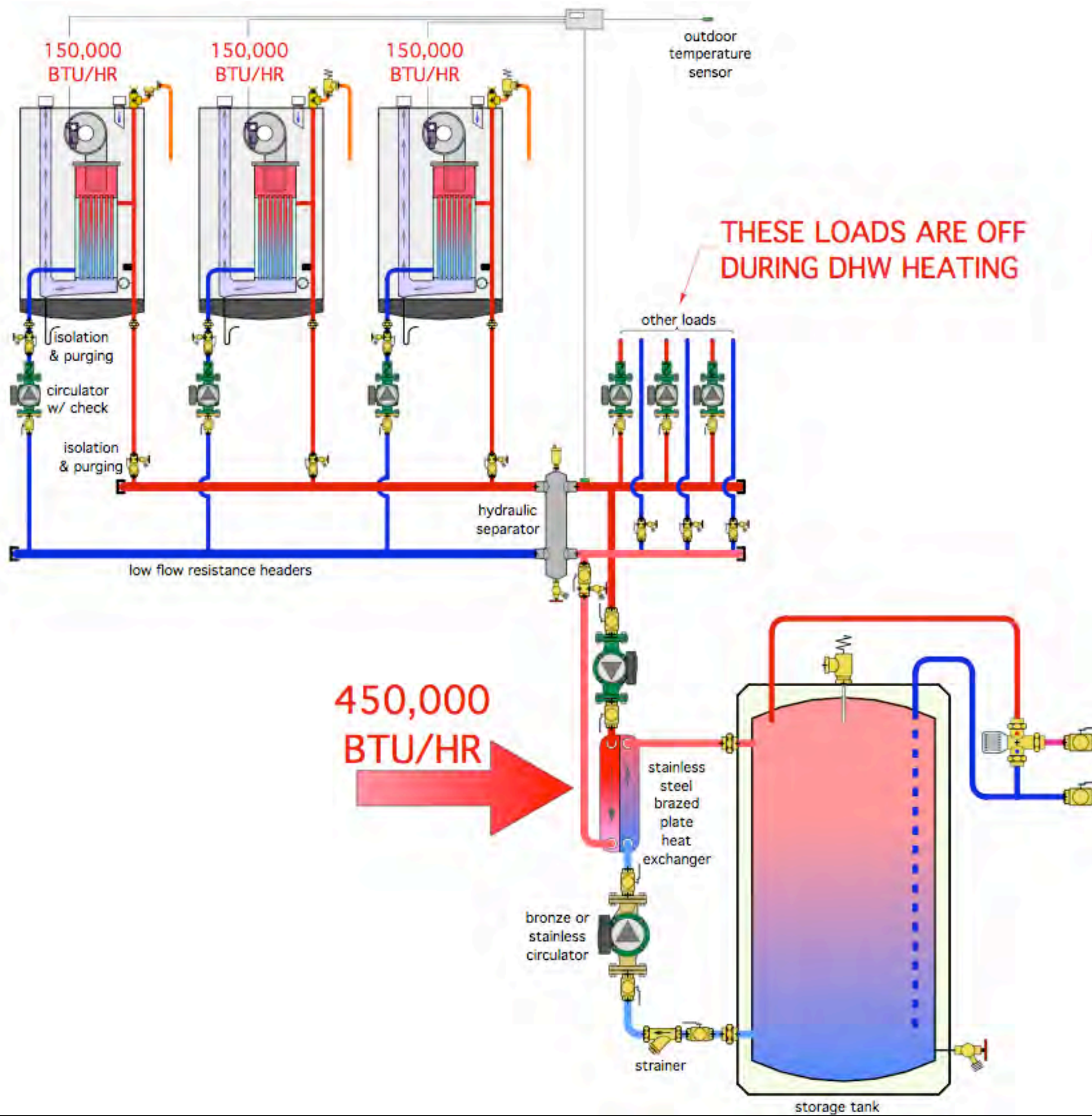
Multiple mod/con boilers for high capacity domestic water heating…

No Bottlenecks! If you're planning a high capacity DHW system it's critically important not to create bottlenecks to heat transfer between the boilers and the domestic water.



- **No FLOW bottlenecks**
- **No HEAT TRANSFER bottlenecks**

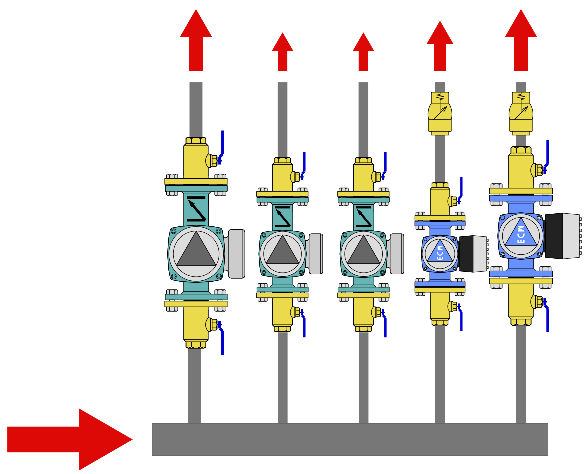
No Bottlenecks: When an indirect tank simply can't provide the necessary heat transfer, use a generously sized stainless steel flat plate heat exchanger with a standard storage tank.



Hydraulic Separation:

Hydraulic Separation:

Think of two circulators, operating simultaneously in the same piping assembly, as rival bullies on the same playground.



When 2 or more circulators are operating simultaneously in the same piping assembly, they try to “interfere” with each other.

This interference is undesirable!

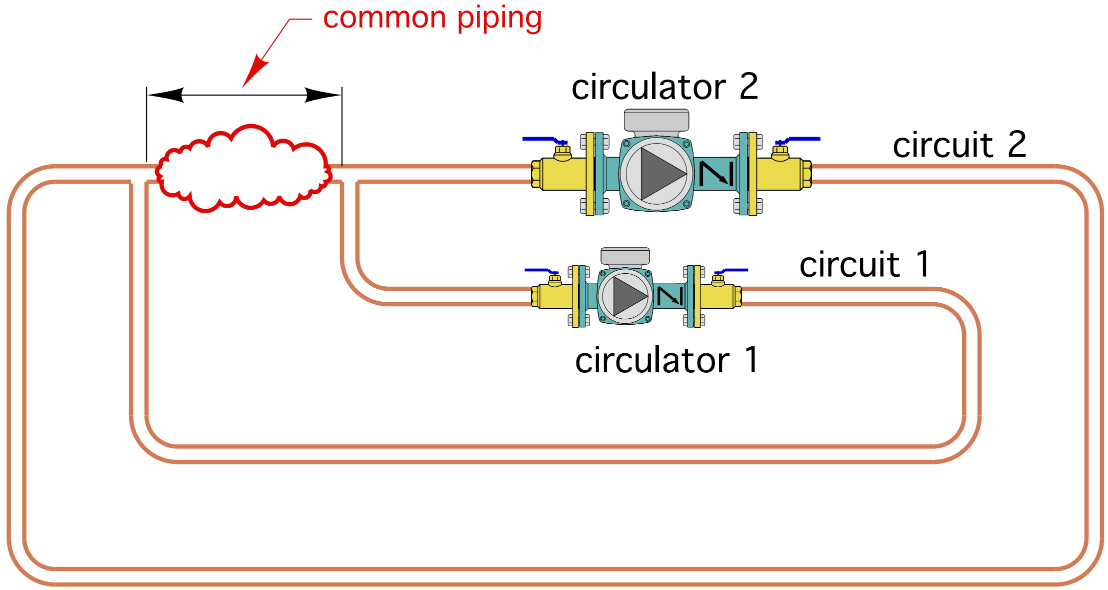
To avoid this interference the circulators need to be “hydraulically separated” from each other.

There are several ways to do this...

MODULE 5: Circulators

Hydraulic Separation: What is “COMMON PIPING?”

It’s the piping components shared by two or more circuits.



The degree to which two or more operating circulators interact with each other depends on the head loss of the common piping.

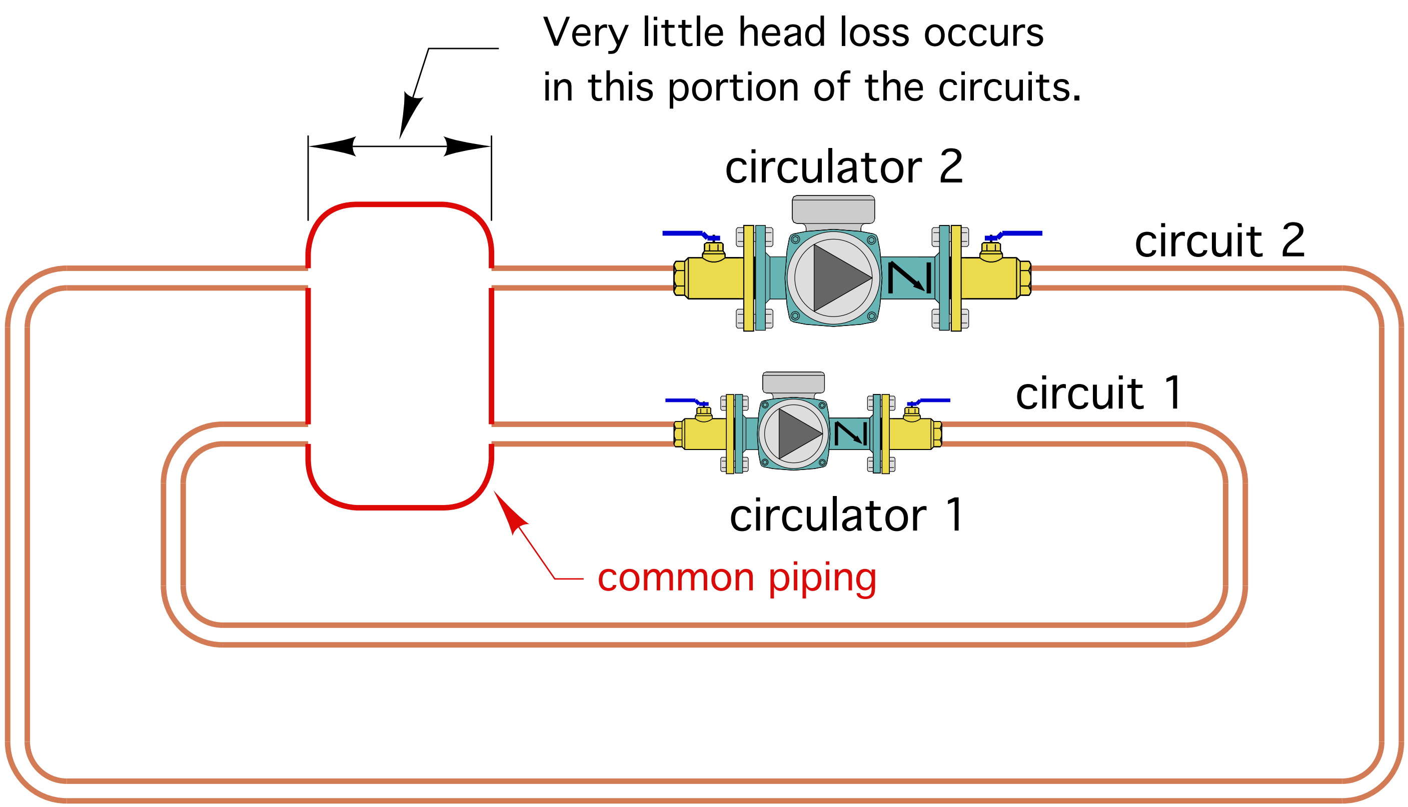
The lower the head loss of the common piping the less the circulators will interfere with each other.

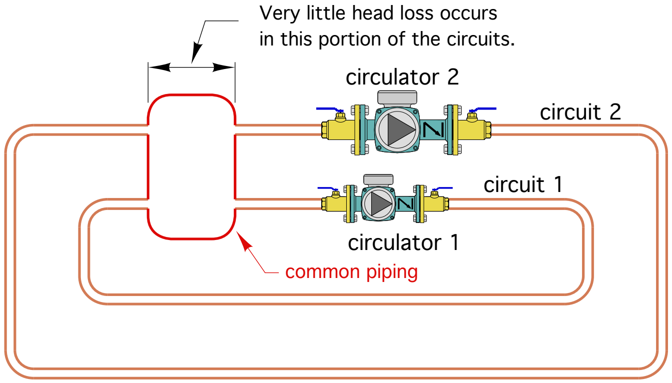
When the head loss of the common piping is very low, there is “hydraulic separation” between the circuits.

MODULE 5: Circulators

Hydraulic Separation:

When the head loss of the common piping is very low, there is "hydraulic separation" between the circuits.





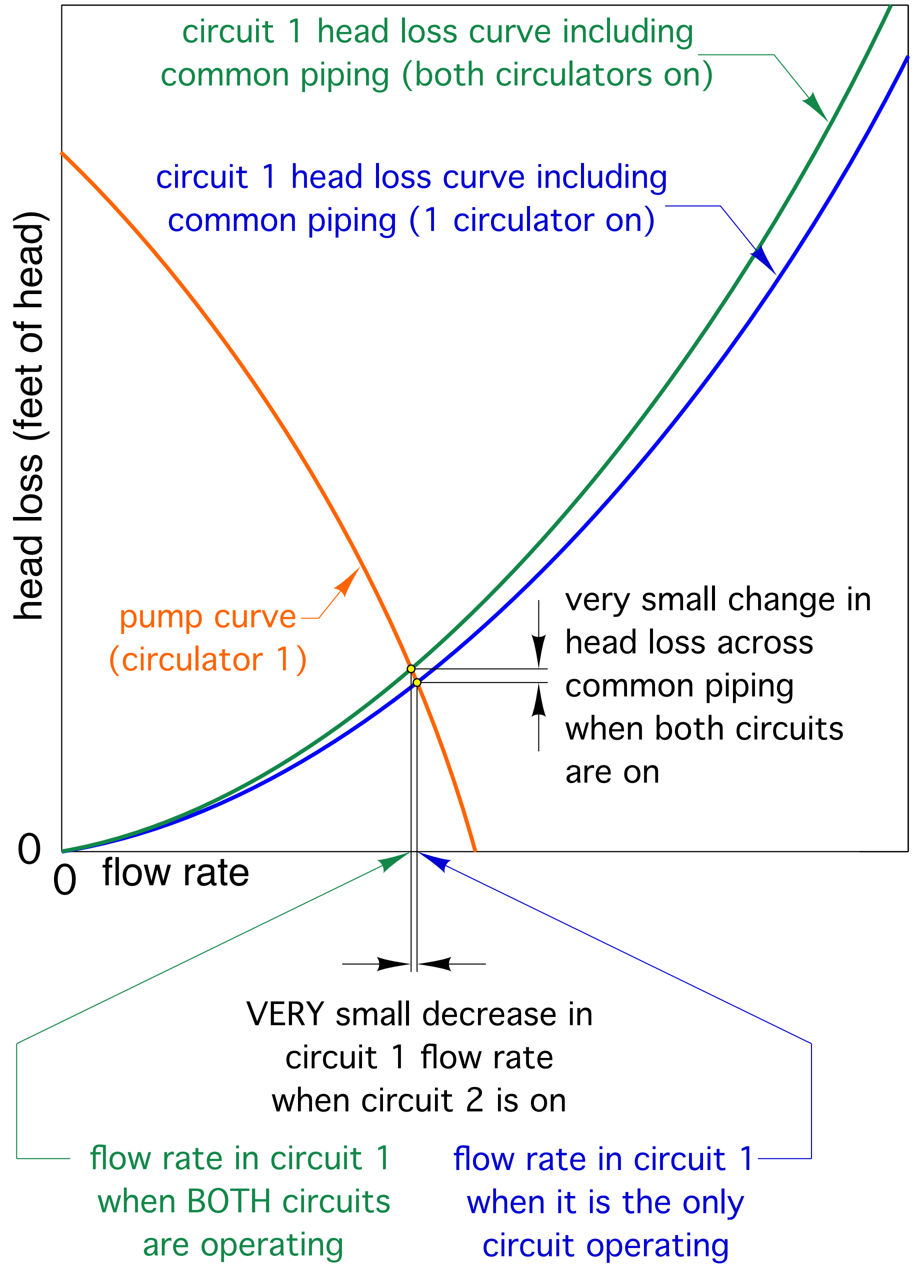
Assume that circulator 1 is operating, but that circulator 2 is off. The lower (blue) system head loss curve in figure 2 applies to this situation.

Next, assume circulator 2 is turned on, and circulator 1 continues to operate.

The flow rate through the common piping increases, and so does the head loss across it.

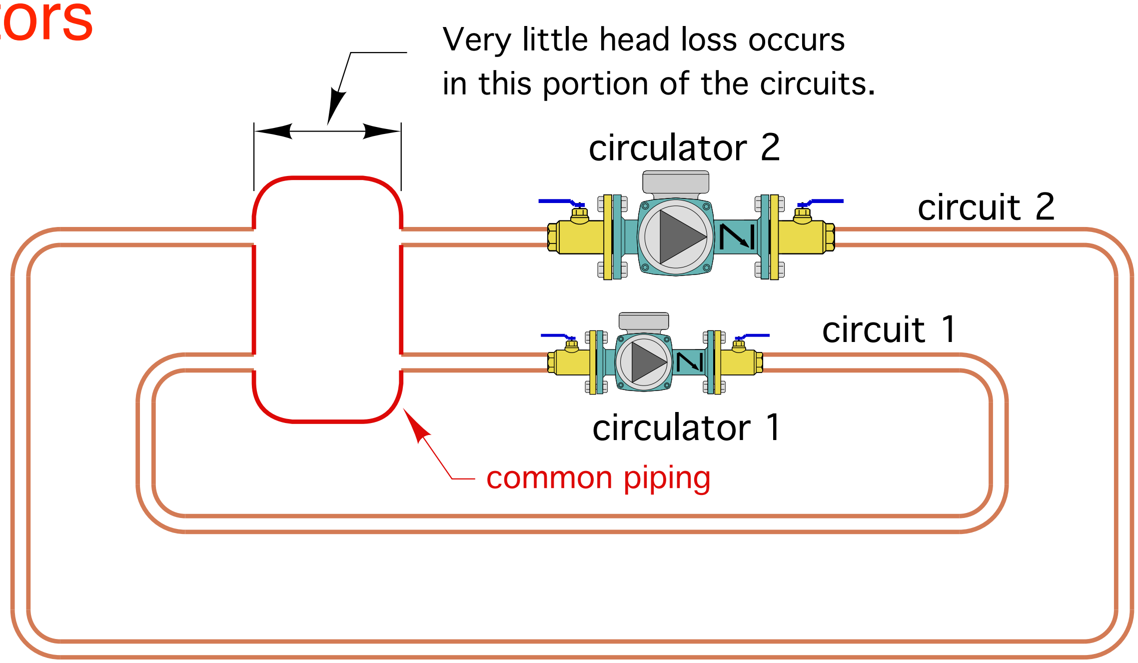
However, because of its spacious geometry, the increase in head loss across the common piping will be very slight. The system head loss curve that is now “seen” by circulator 1 has very slightly steepened. It is the upper, (green) curve shown in figure 2.

The operating point of circuit 1 has moved very slightly to the left, and as a result, the flow rate through circuit 1 has decreased very slightly.



MODULE 5: Circulators

Hydraulic Separation:



Imagine a hypothetical situation in which the head loss across the common piping was *zero*, even with both circuits operating.

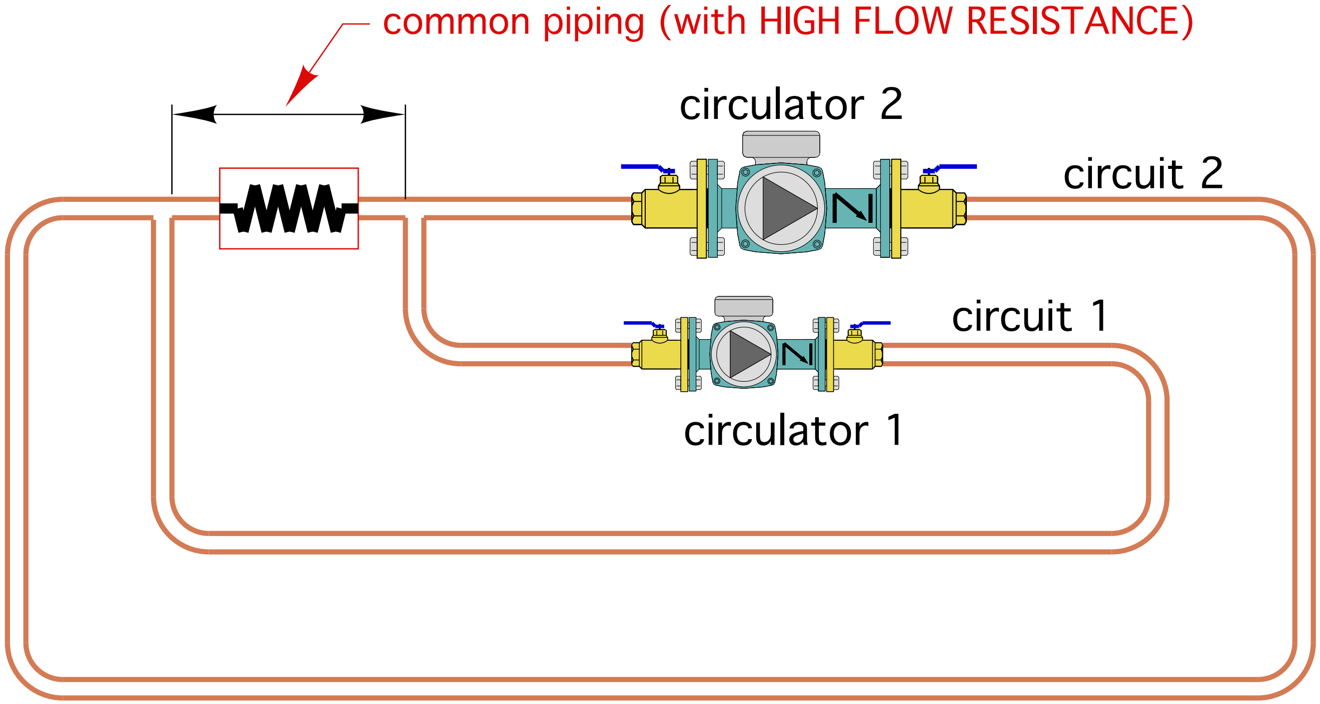
Because **NO** head loss occurs across the common piping, it would be impossible for either circulator to "influence" the other circulator.

This would be "perfect" hydraulic separation.

Design tip: perfect hydraulic separation is not required to ensure that the flow rates through independently operated circuits remain reasonably stable.

MODULE 5: Circulators

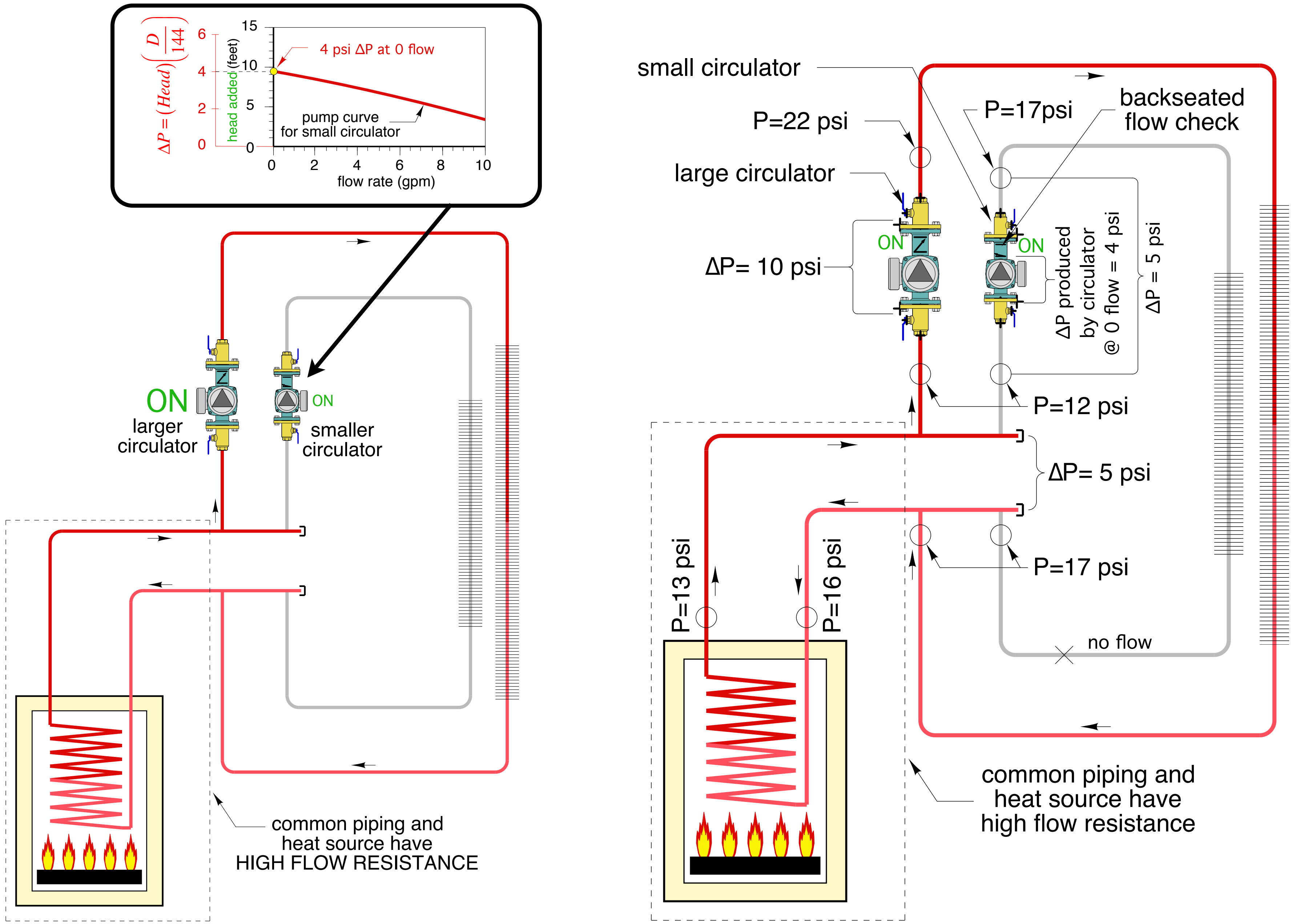
Hydraulic Separation:



The higher the flow resistance of the common piping, the more each circulator will “influence” flow in the other circuit (e.g. the lower the hydraulic separation of the circuits).

Design tip: Common piping with high flow resistance is NOT good:

High flow resistance common piping - something to avoid

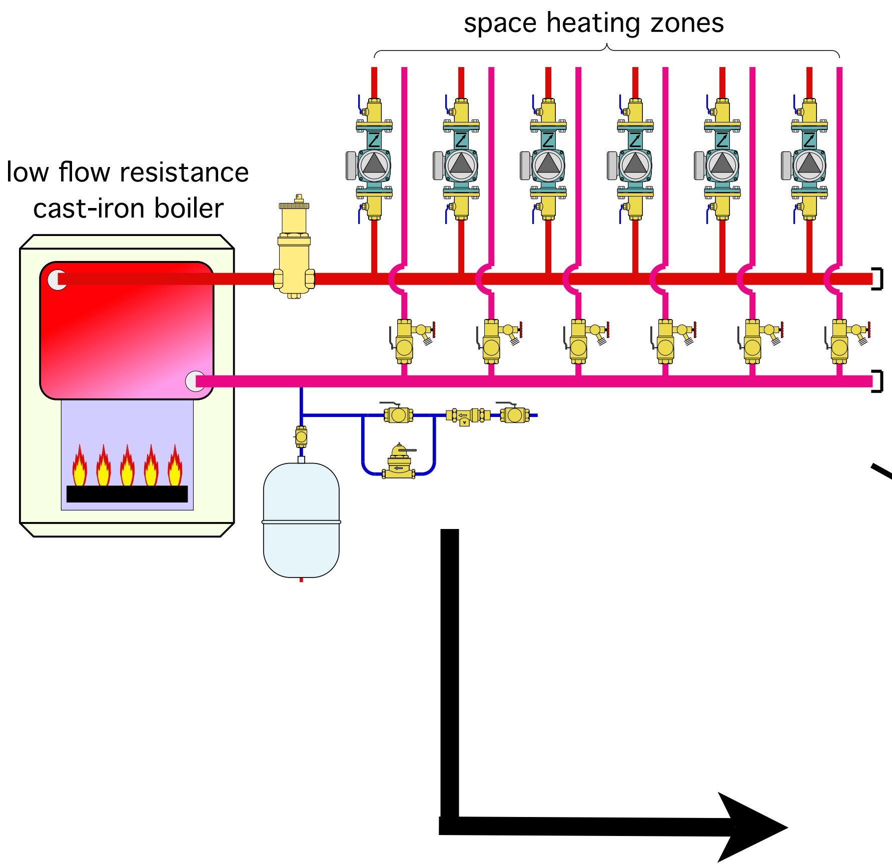


MODULE 5: Circulators

Hydraulic Separation:

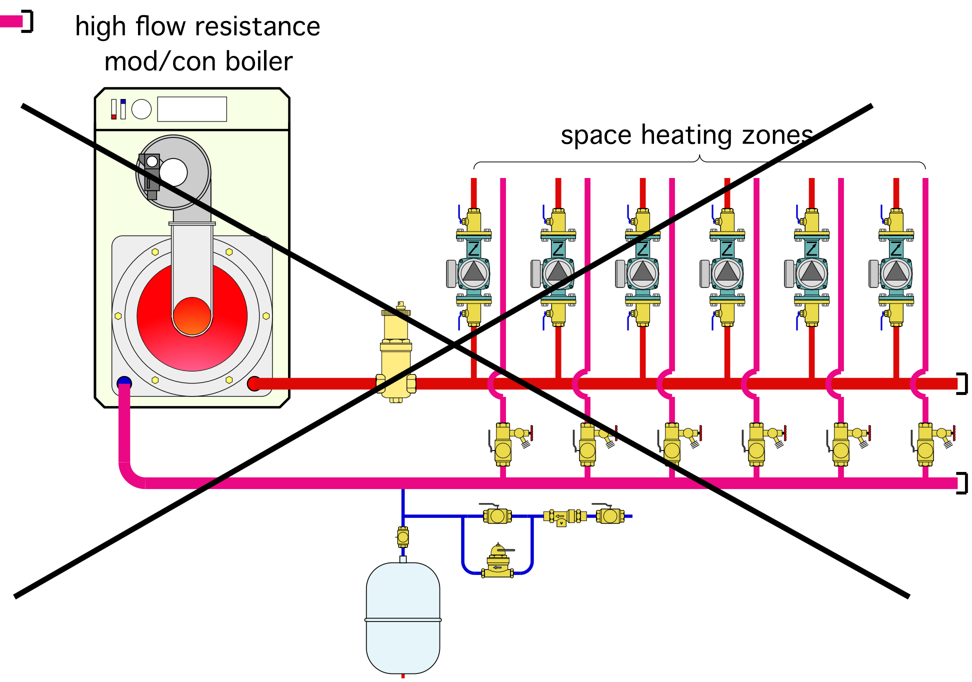
Conventional cast-iron boilers have very **low** flow resistance.

Modern compact boilers have ***much higher*** flow resistance.



If a compact boiler is “cut and soldered” in place to replace a cast iron boiler,

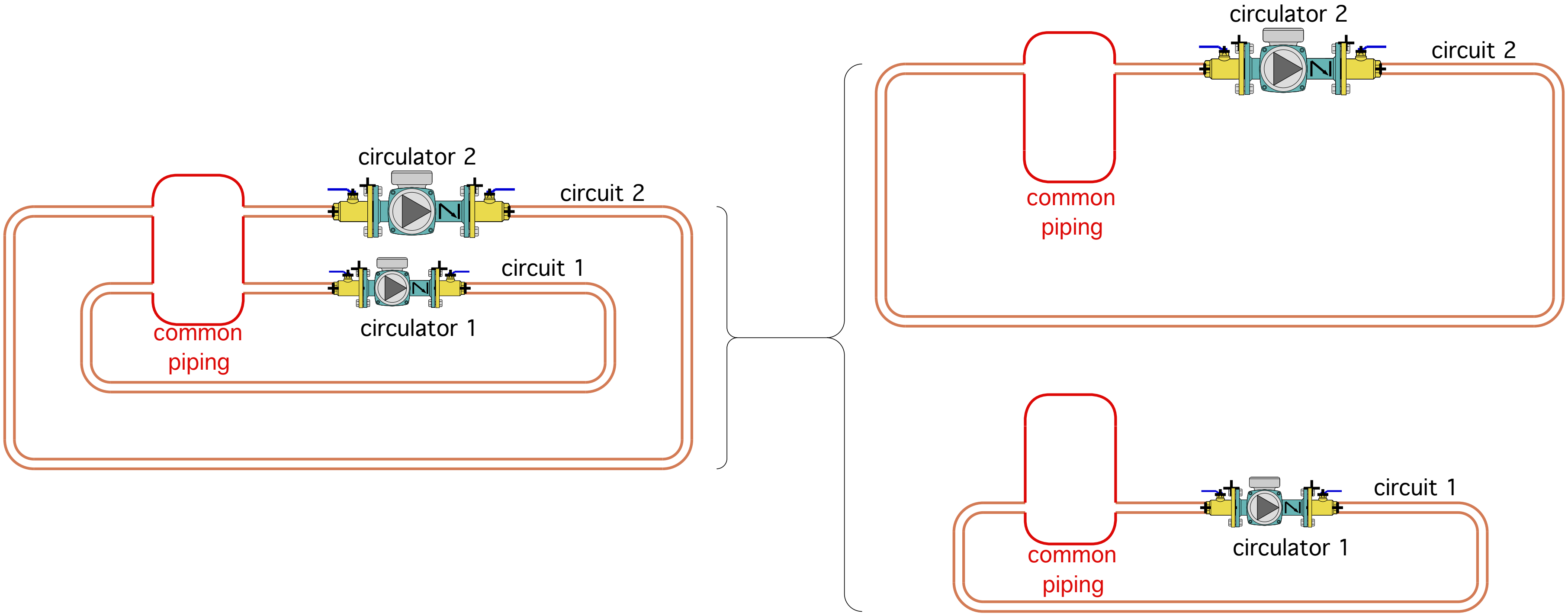
Interference between simultaneously operating circulators is likely.



MODULE 5: Circulators

Hydraulic Separation: **Divide & Conquer:**

From the standpoint of hydraulics, each circuit can be designed as if it's a stand-along circuit.

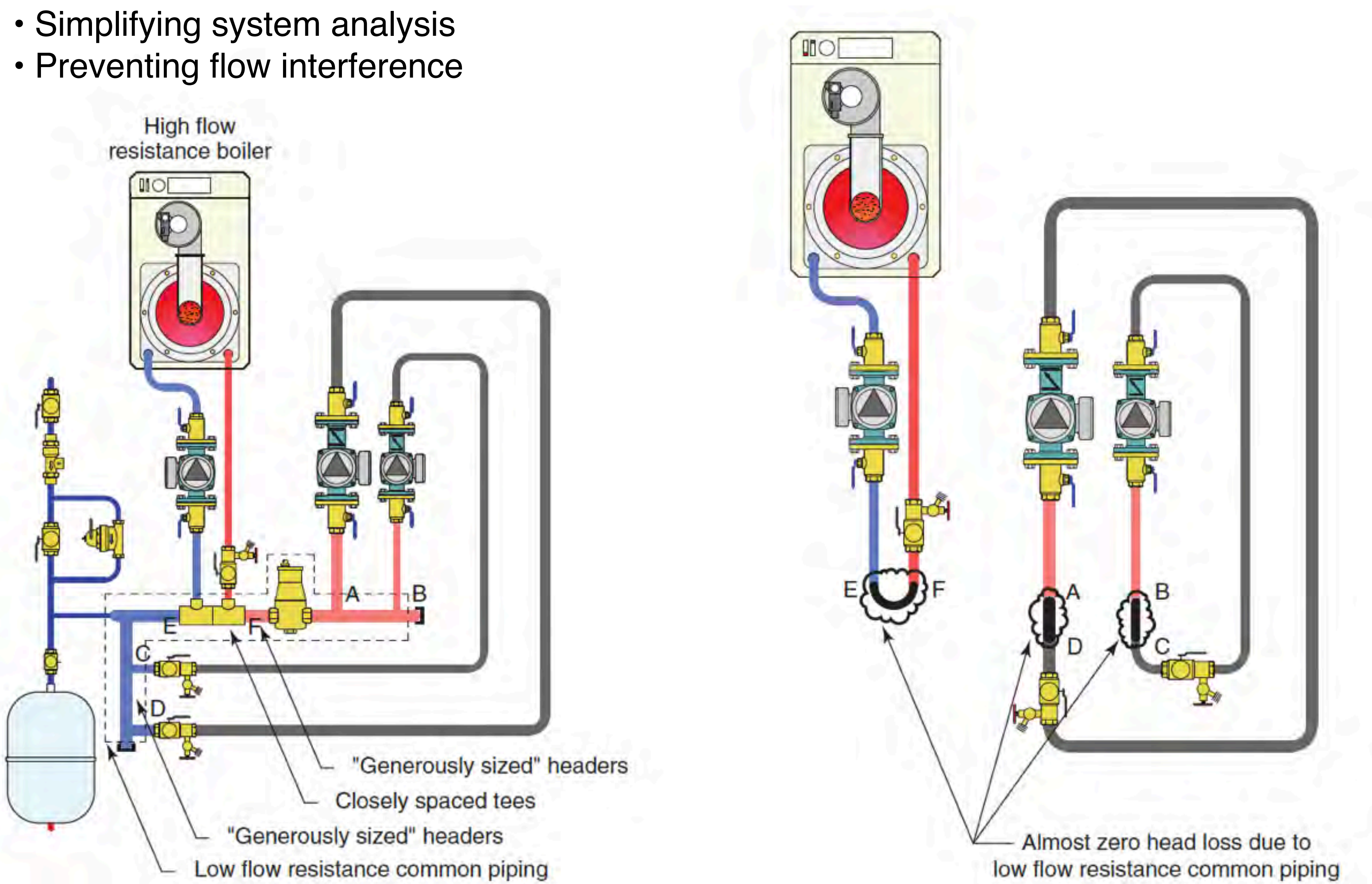


Design tip: Hydraulic separation allows designers to think of an overall system as a collection of independent ("hydraulically isolated) circuits.

MODULE 5: Circulators

Hydraulic Separation: **Divide & Conquer:**

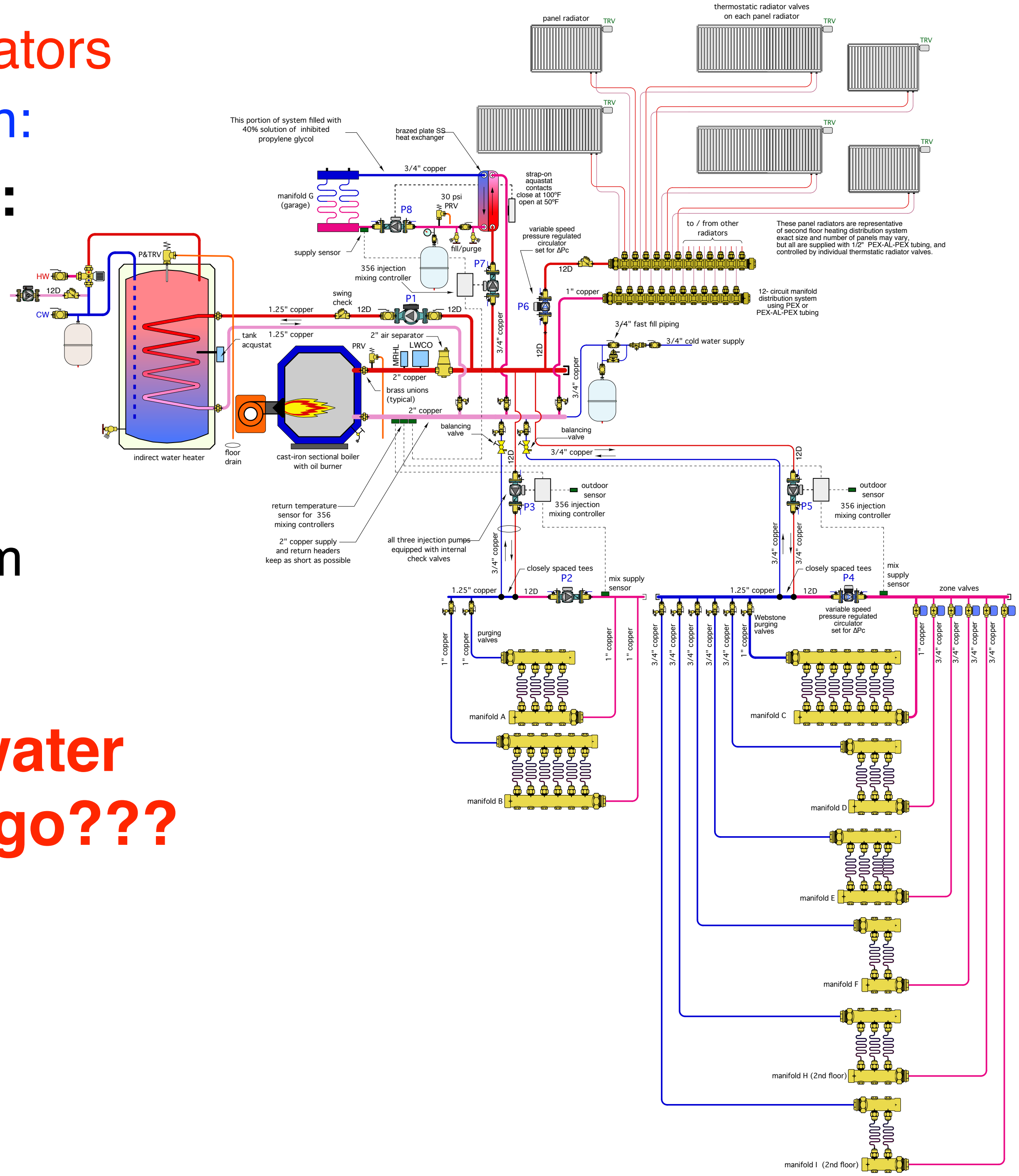
- Simplifying system analysis
- Preventing flow interference



MODULE 5: Circulators

Hydraulic Separation:

Divide & Conquer:



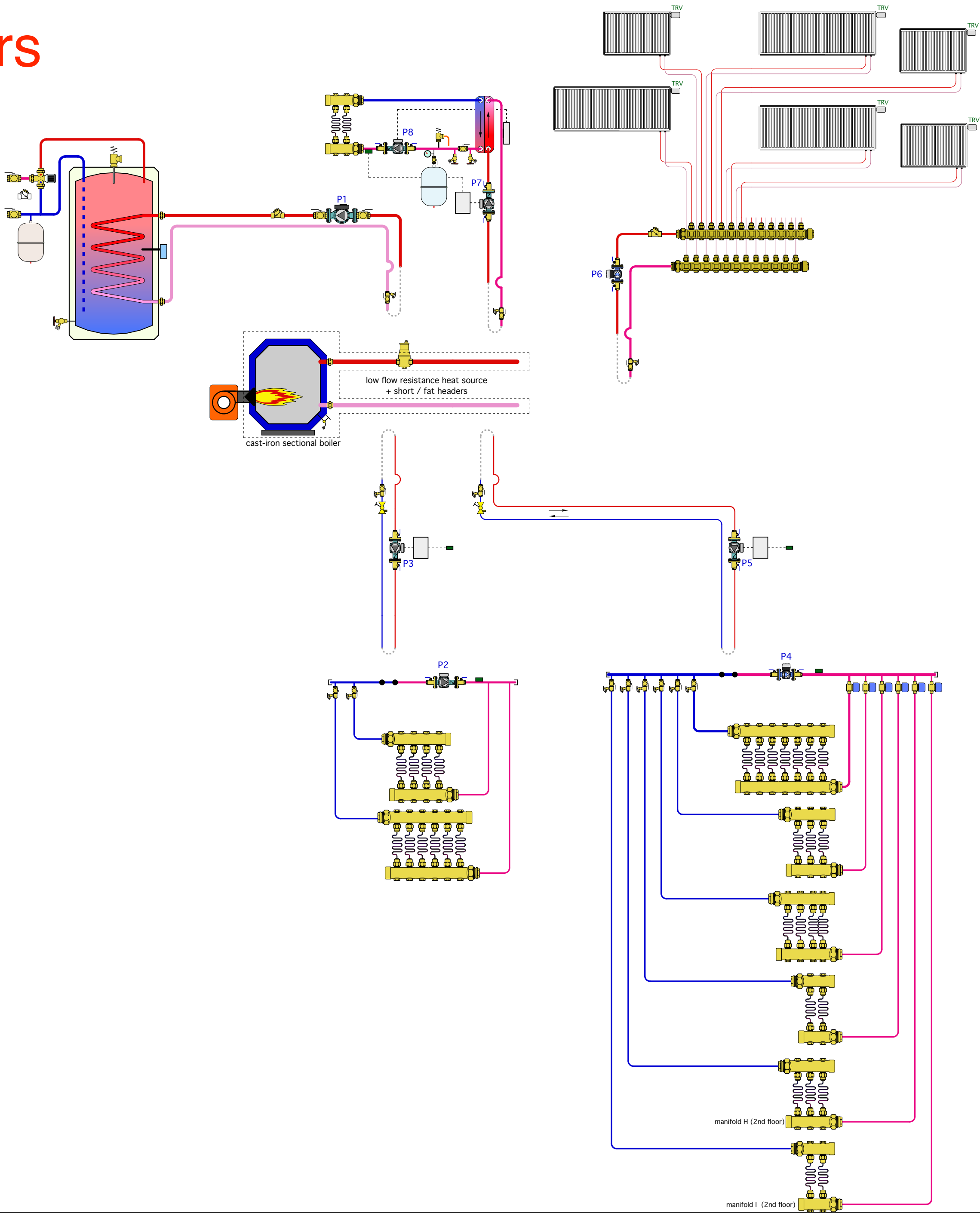
In a complex system like this...

How does the water know where to go???

MODULE 5: Circulators

Hydraulic Separation:

Divide & Conquer:



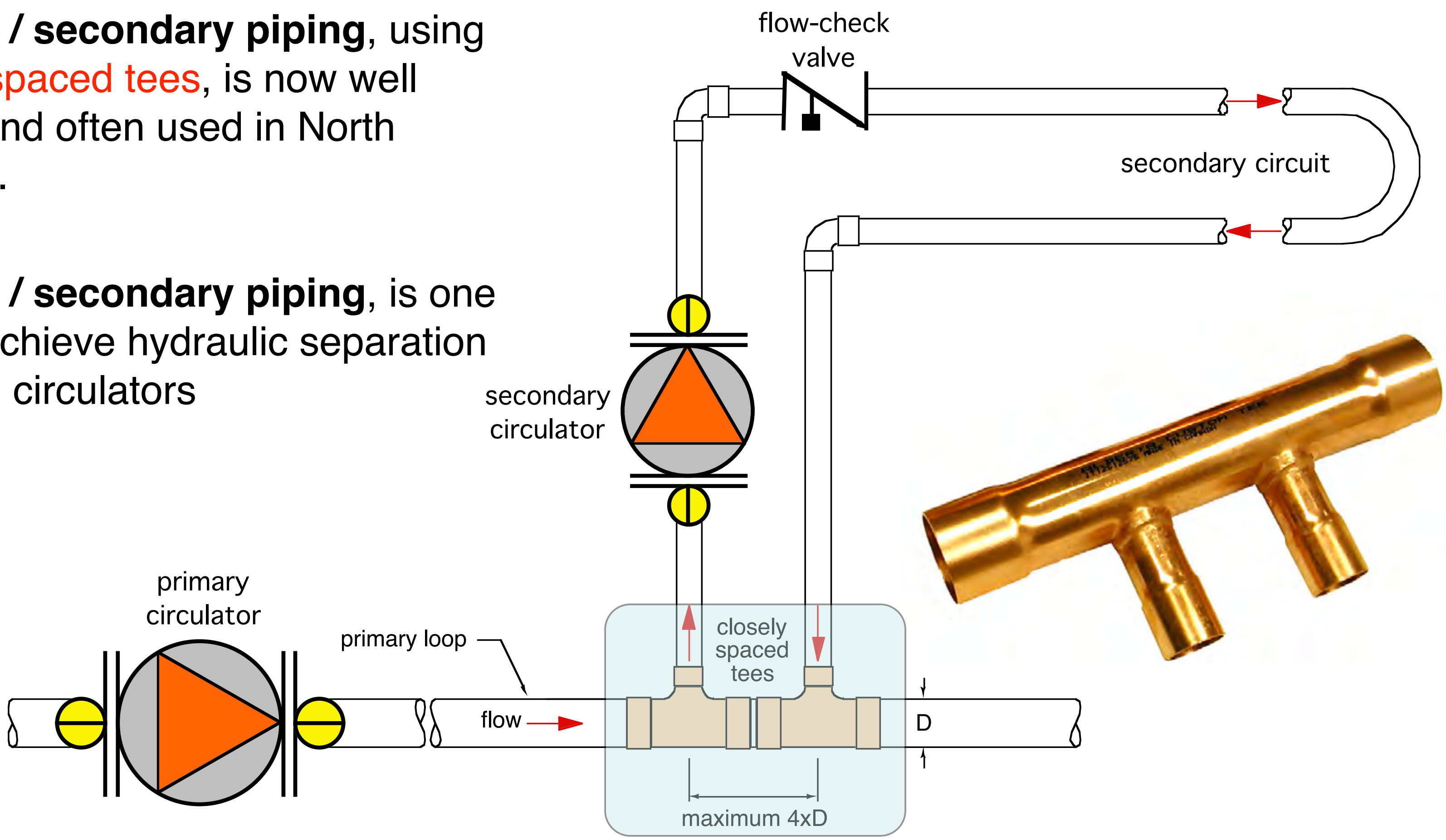
Hydraulic separation allows designers to think of an overall system as a collection of independent ("hydraulically isolated) circuits.

In this system, hydraulic separation was achieved using "short / fat" header in combination with low flow resistance heat source.

Primary / Secondary piping - *where it all began...*

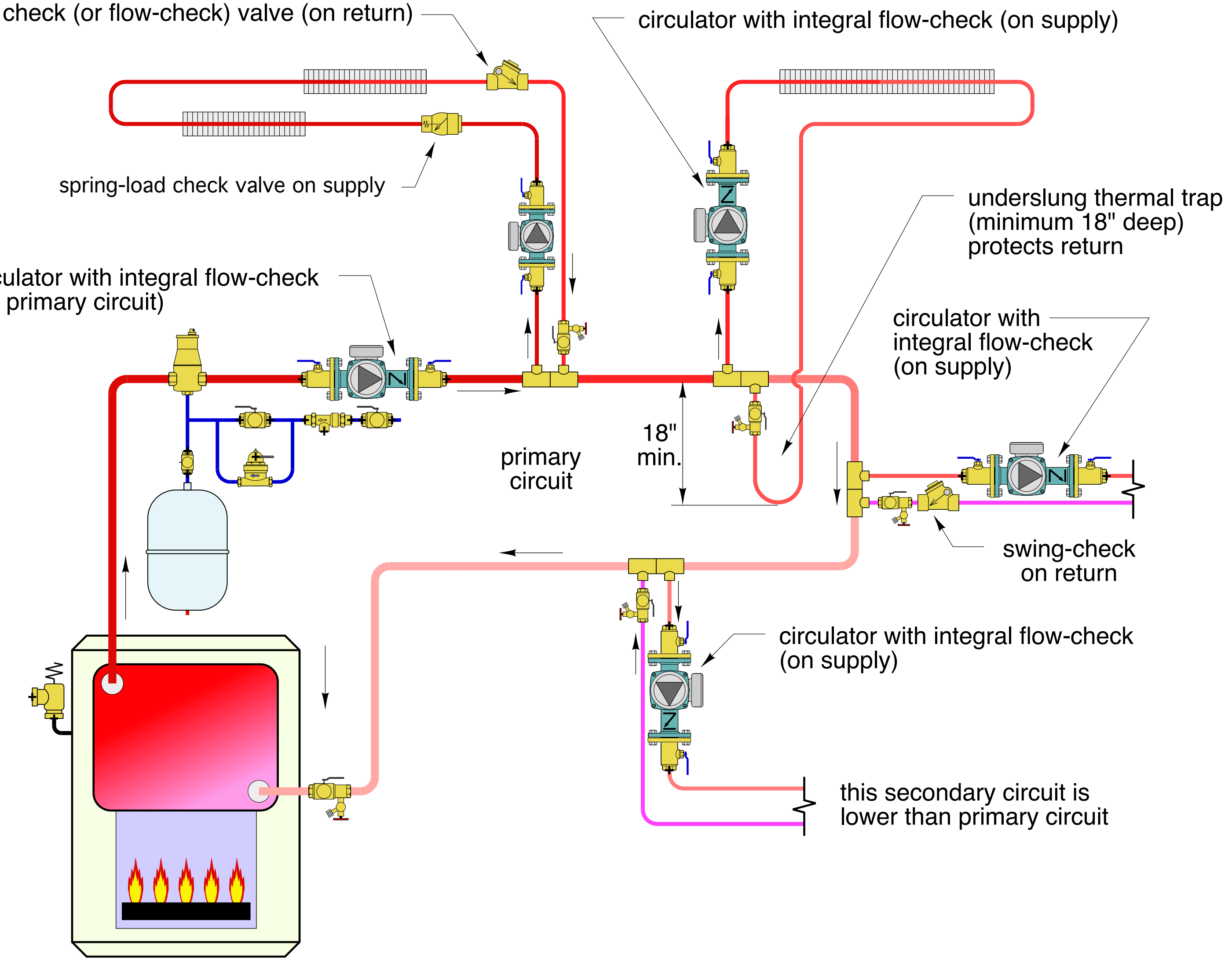
Primary / secondary piping, using closely spaced tees, is now well known and often used in North America.

Primary / secondary piping, is one way to achieve hydraulic separation between circulators



But primary / secondary piping is not the ONLY way to create hydraulic separation...

Primary / secondary piping (one way to provide hydraulic separation)



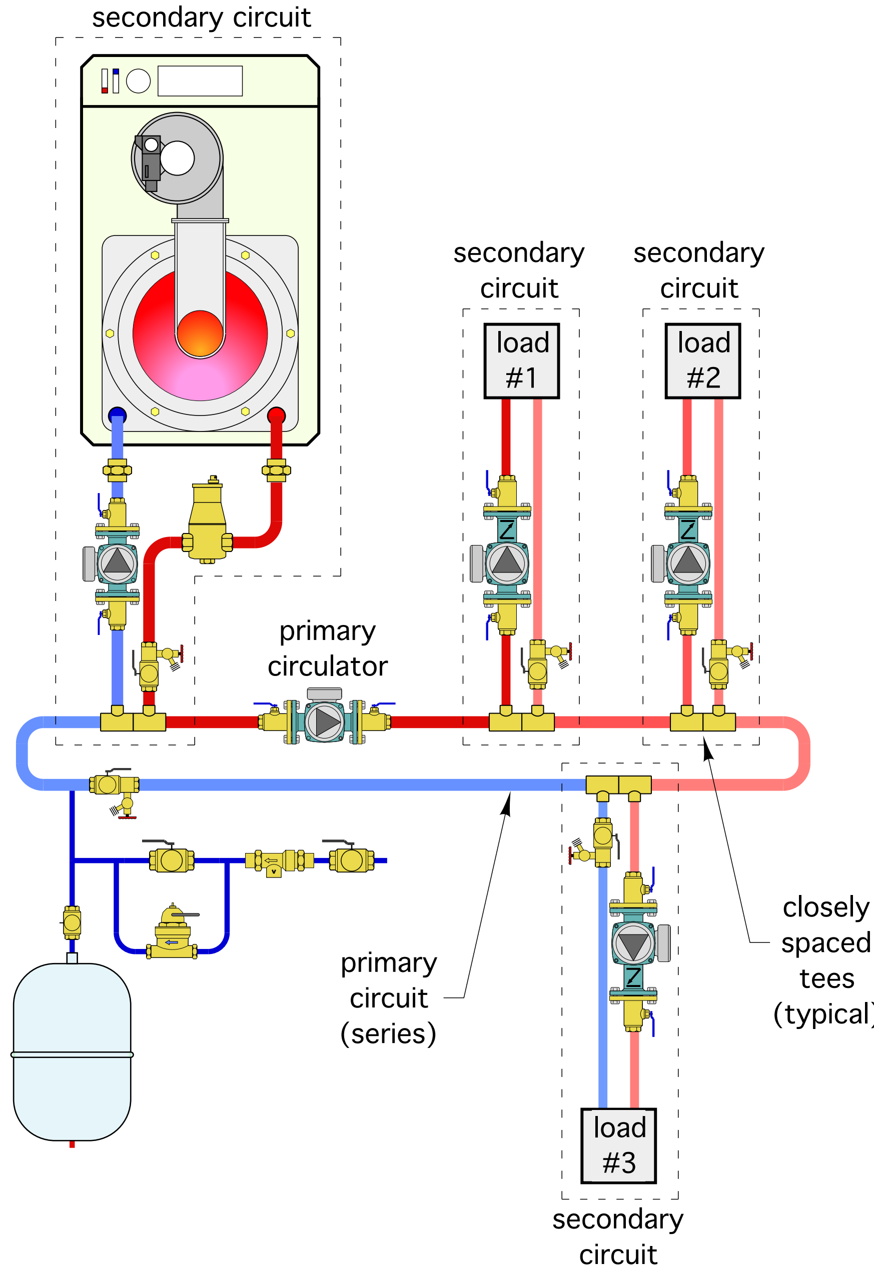
This is a SERIES primary loop. It will create a sequential drop in water temperature from one secondary circuit to the next.

Primary / Secondary piping - *where it all began...*

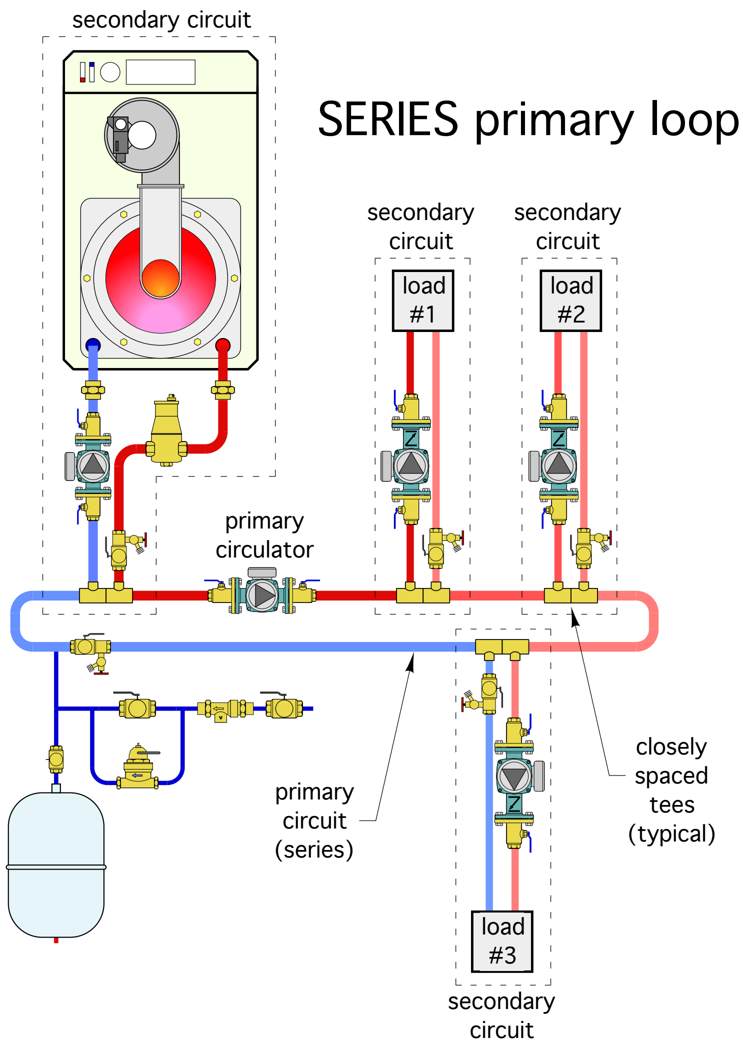
Primary / secondary piping, using closely spaced tees, is now well known and often used in North America.

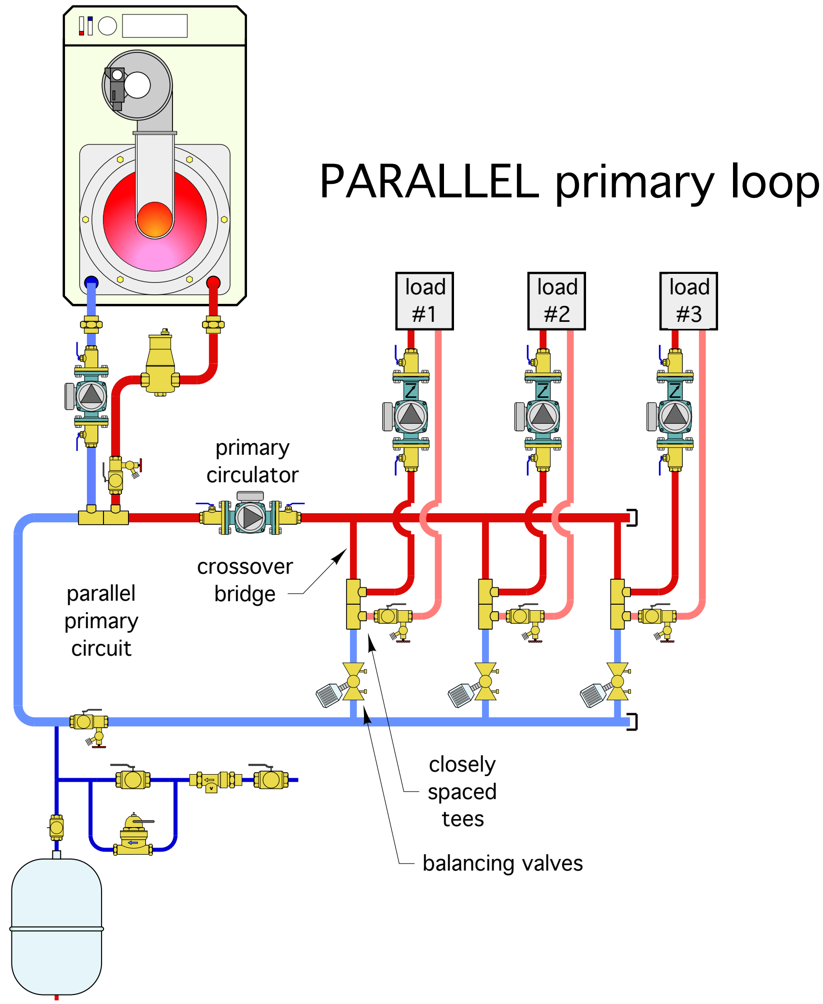
Primary / secondary piping, is one way to achieve hydraulic separation between circulators.

But primary / secondary piping is not the ONLY way to create hydraulic separation...



Series and parallel primary/secondary systems





Both series and parallel primary/secondary systems **require a primary circulator.**

This adds to the installed cost of the system AND **adds hundreds, even thousands of dollars in operating cost** over a typical system life.

An example of primary loop circulator operating cost:

Consider a system that supplies 500,000 Btu/hr at design load. Flow in the primary loop is 50 gpm with a corresponding head loss of 15 feet (6.35 psi pressure drop). Assume a wet rotor circulator with wire-to-water efficiency of 25 is used as the primary circulator.

The input wattage to the circulator can be estimated as follows:

$$W = \frac{0.4344 \times f \times \Delta P}{0.25} = \frac{0.4344 \times 50 \times 6.35}{0.25} = 552 watts$$

Assuming this primary circulator runs for 3000 hours per year its first year operating cost would be:

$$\text{1st year cost} = \left(\frac{3000hr}{yr}\right)\left(\frac{552w}{1}\right)\left(\frac{1kwhr}{1000whr}\right)\left(\frac{\$0.10}{kwhr}\right) = \$165.60$$

An example of primary loop circulator operating cost:

Assuming electrical cost escalates at 4% per year the total operating cost over a 20-year design life is:

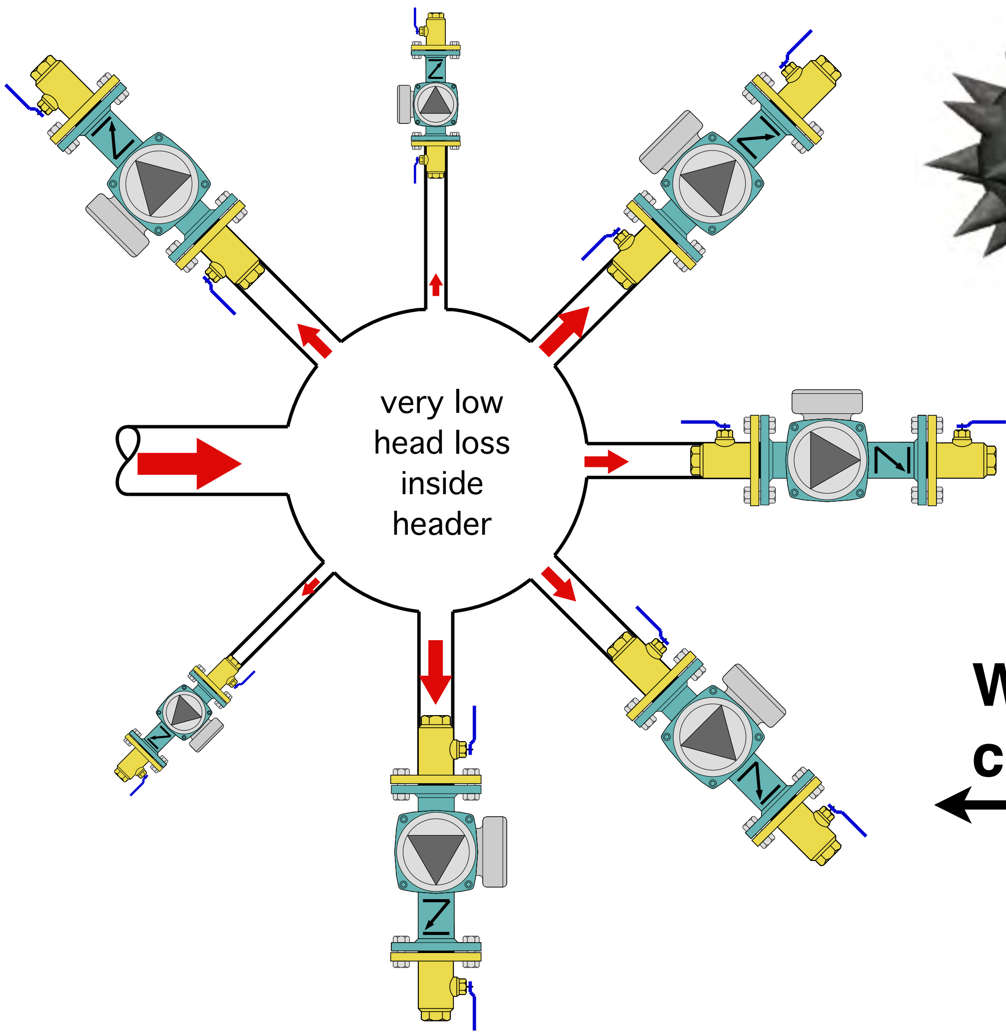
$$c_T = c_1 \times \left(\frac{(1+i)^N - 1}{i} \right) = \$165.60 \times \left(\frac{(1+0.04)^{20} - 1}{0.04} \right) = \$4,931$$

This, combined with eliminating the multi-hundred dollar installation cost of the primary circulator obviously results in significant savings.

Question: What is the "ideal" header in a hydronic system?

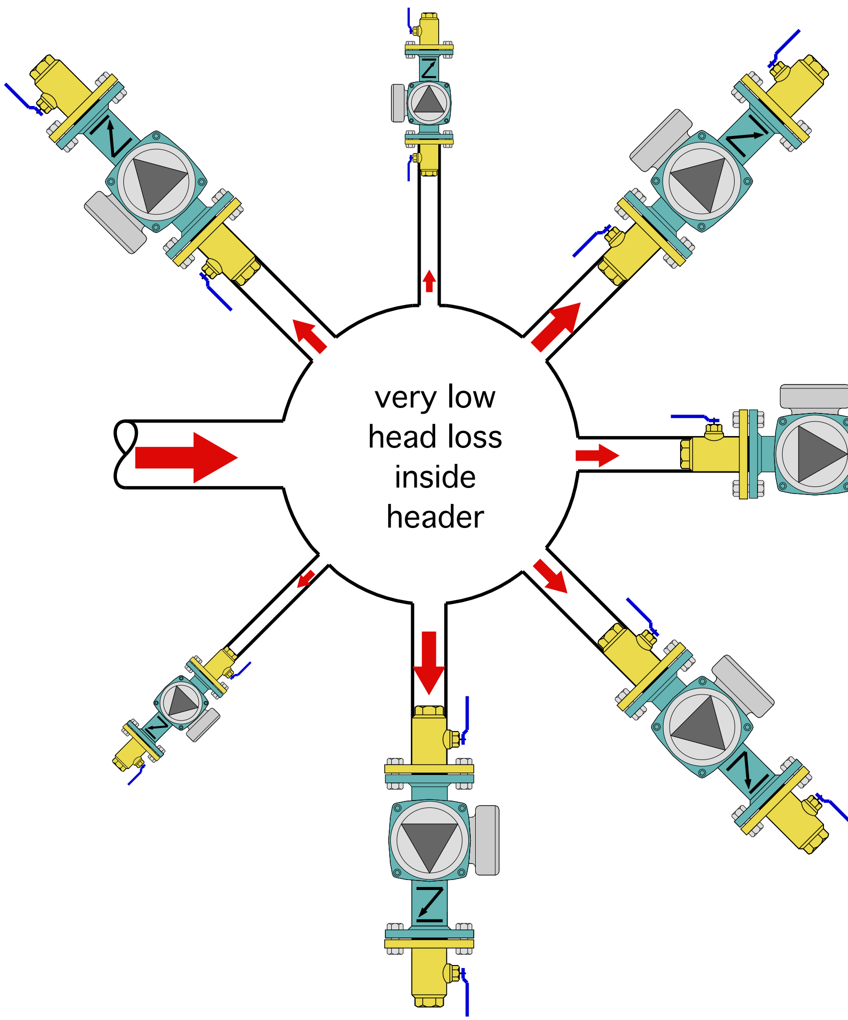
Answer: One that splits up the flow without creating head loss

Think about a "**copper basketball**" with pipes sticking out of it in all directions.

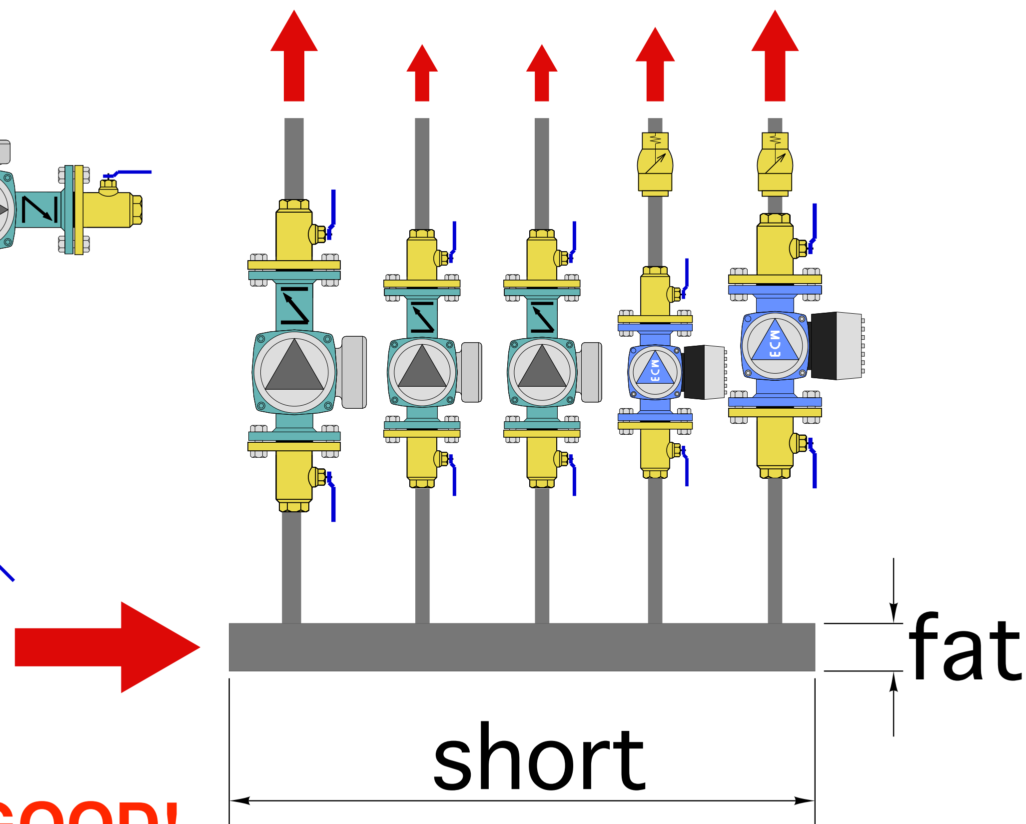


Wouldn't this be pretty close to an ideal header???

So why don’t we build headers like this???



Instead, we approximate the ideal header by making it “short” & “fat”



“Short / fat” headers are GOOD!

Long / skinny headers are BAD!