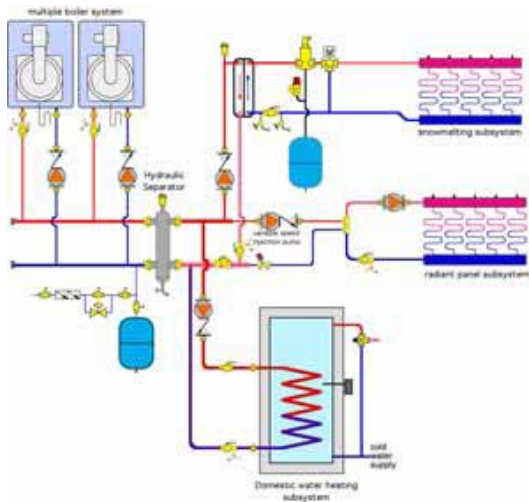




Hydraulic Separation

Beyond Primary / Secondary Piping



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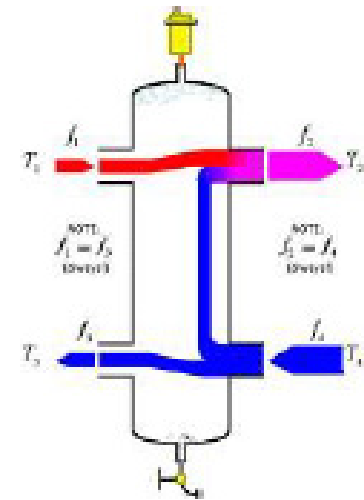
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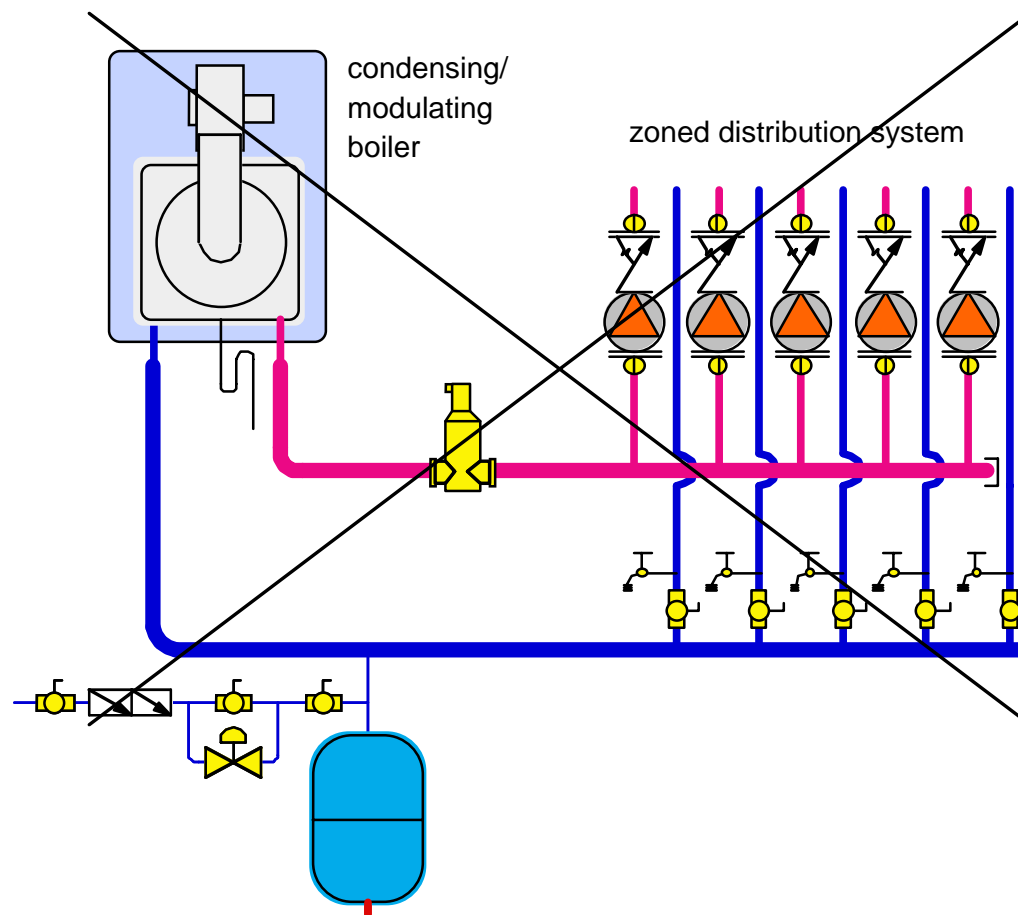
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Modern compact boilers have much higher flow resistance than cast iron boilers.

If they are simply substituted for cast iron boiler problems are likely to develop, most notably **interference between simultaneously operating circulators**.



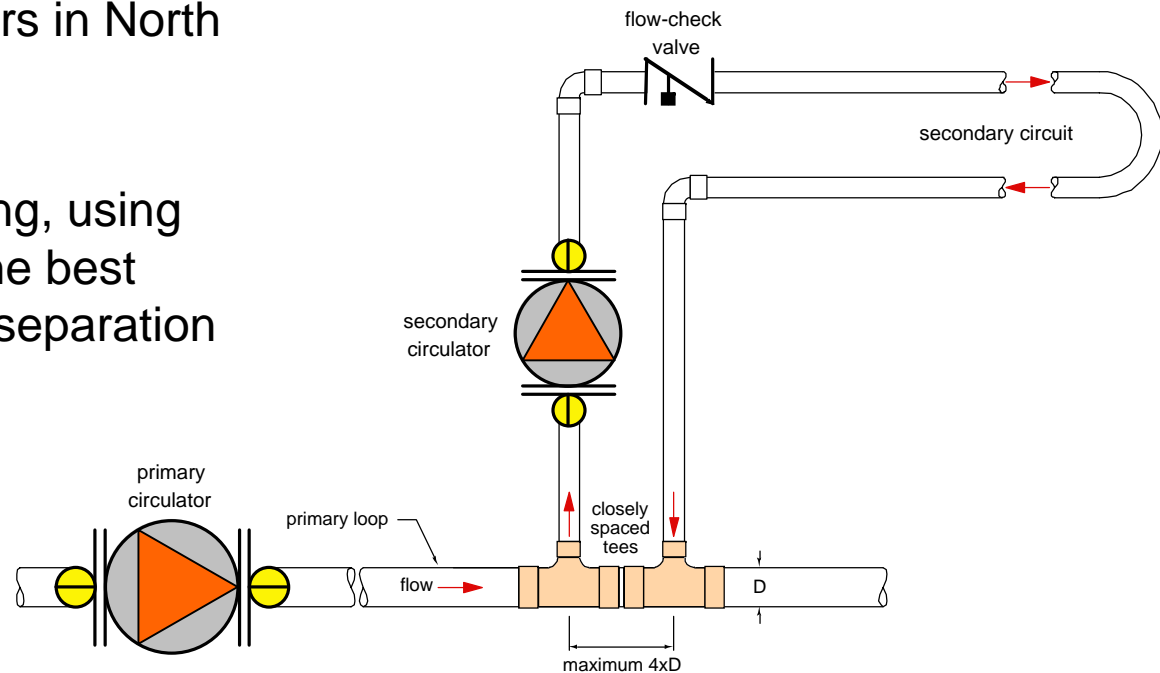
The solution to this problem is **hydraulic separation**. In short, preventing flow in one circuit from interfering with flow in another circuit.

In systems with hydraulic separation the designer can now *think of each circuit as a “stand-alone” entity*:

- Simplifying system analysis
- Preventing flow interference

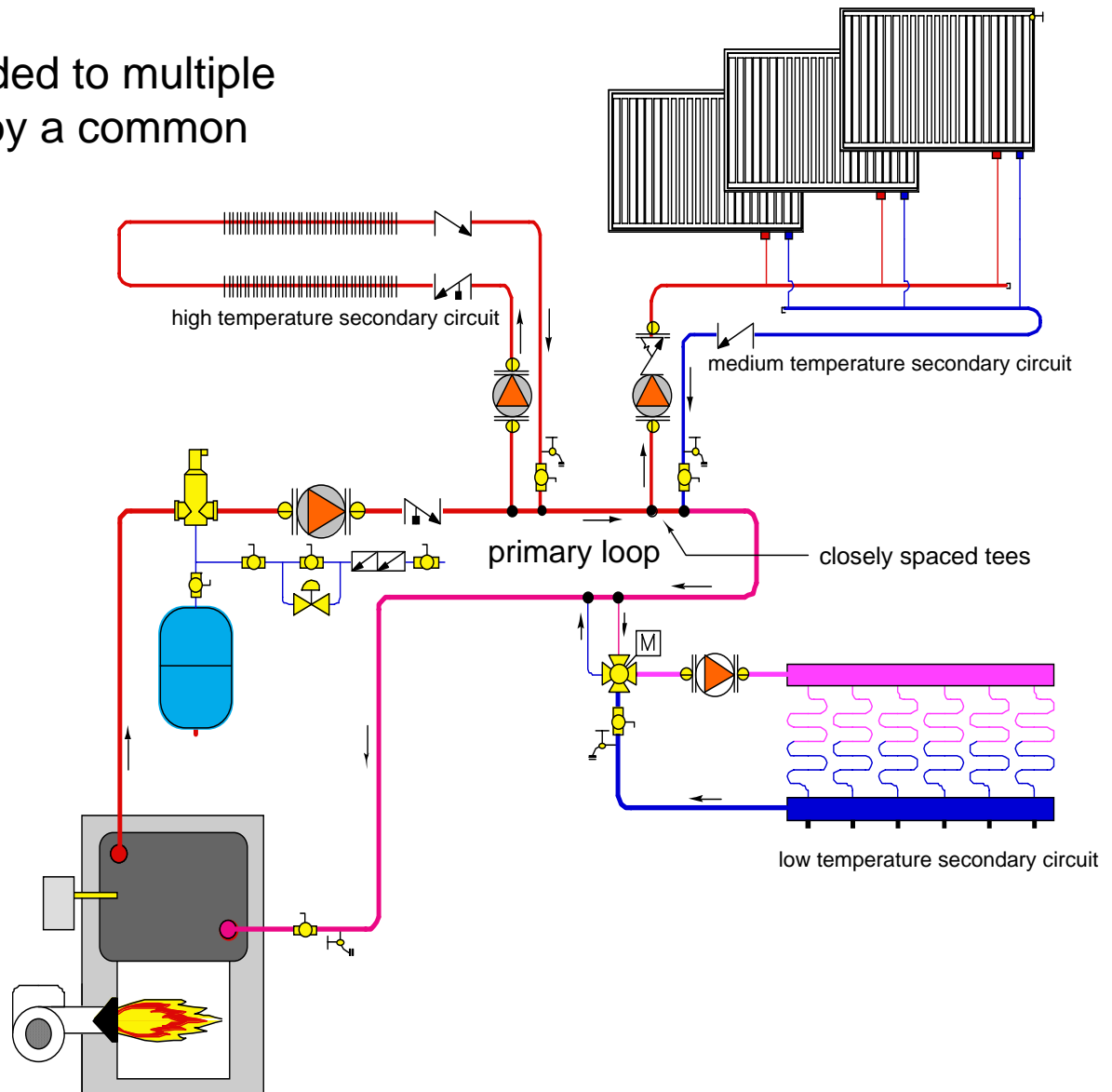
Hydraulic separation is a new term to hydronic system designers in North America.

Primary / secondary piping, using **closely spaced tees**, is the best known form of hydraulic separation now used in North America



The secondary circuit is “hydraulically separated” from the primary circuit by the closely spaced tees.

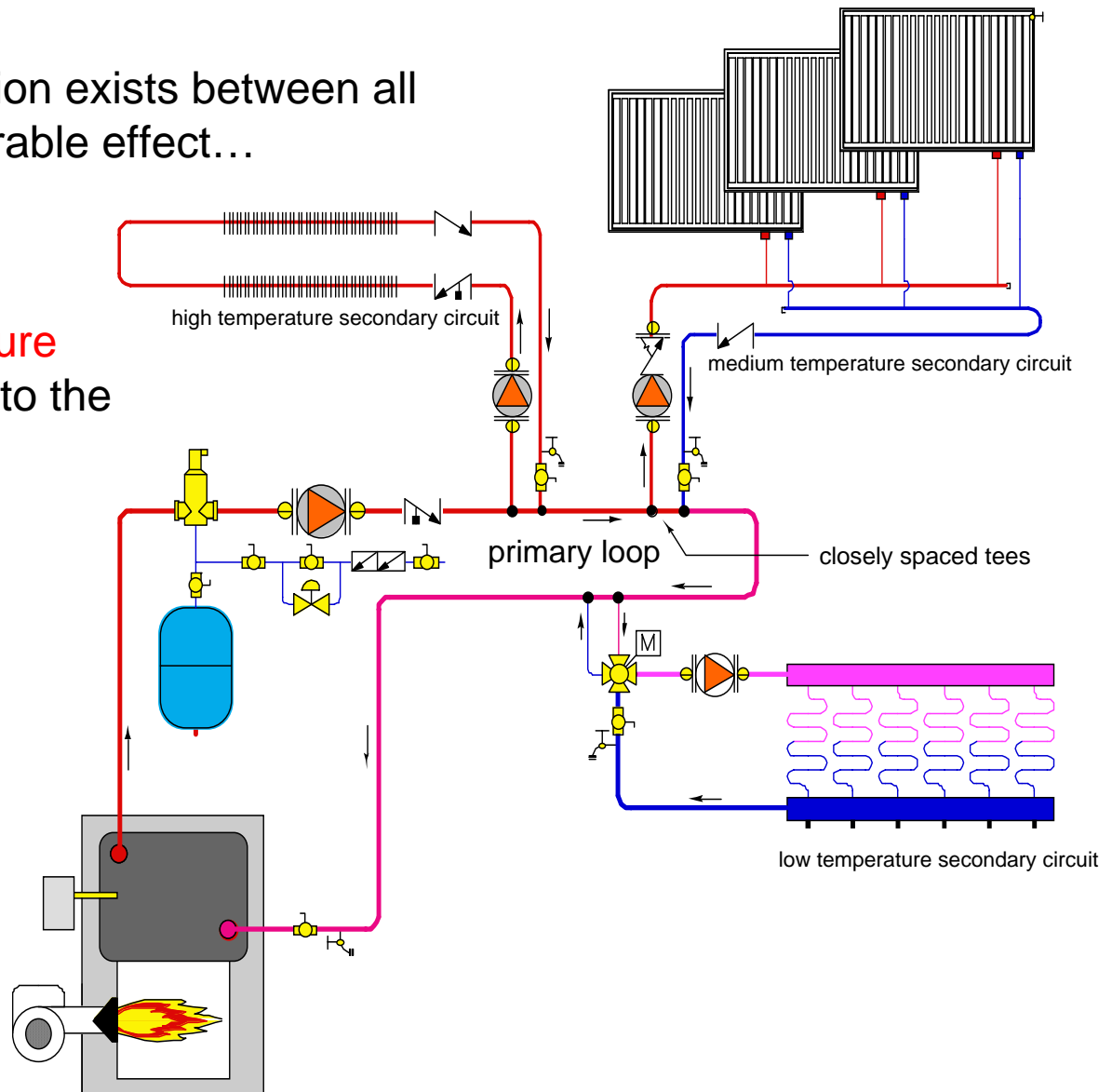
This concept can be extended to multiple secondary circuits served by a common primary loop:



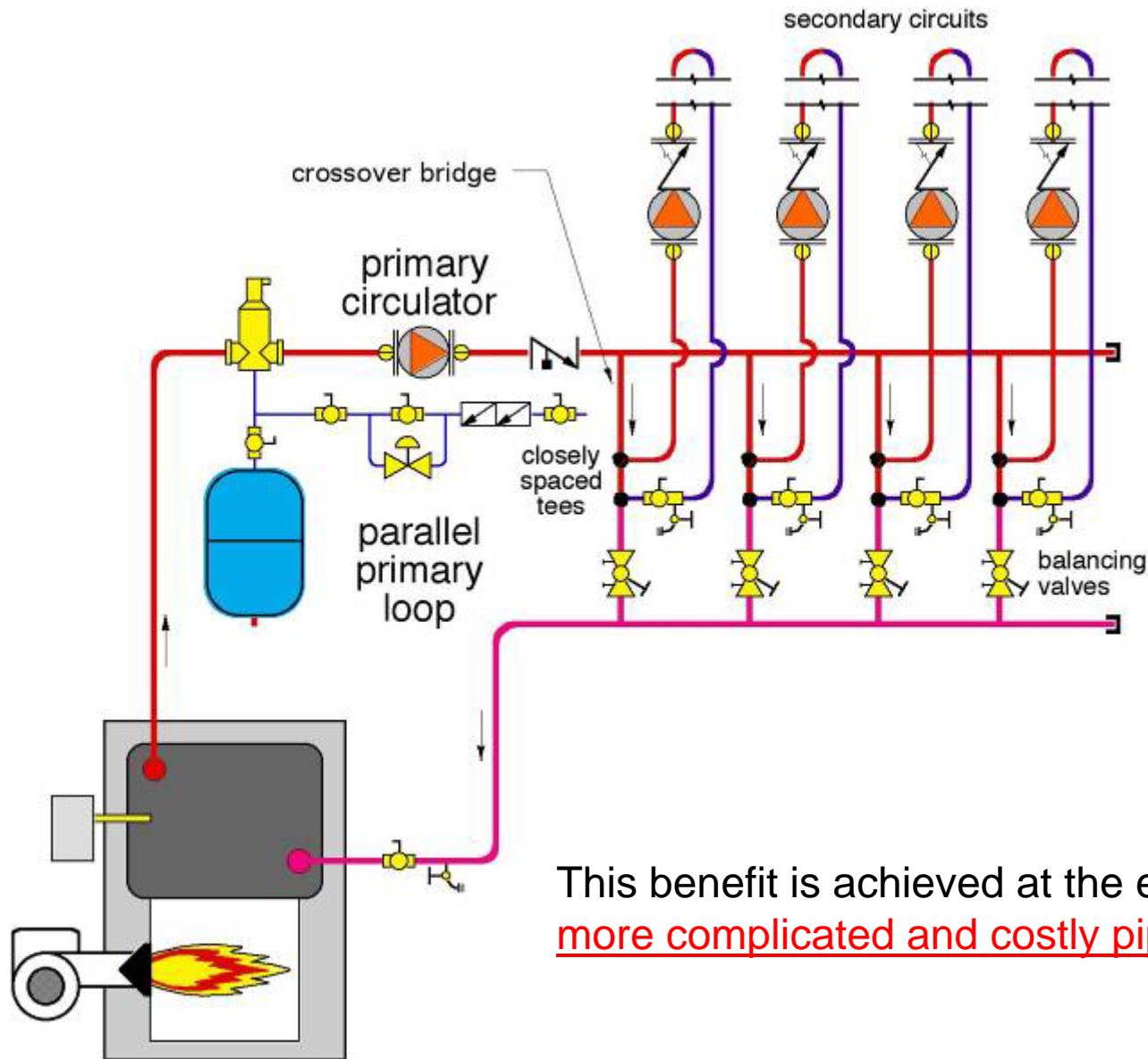
This configuration is more called a **series** primary/secondary system:

Although hydraulic separation exists between all circuits, so does an undesirable effect...

...a **drop in water temperature** from one secondary circuit to the next when operating simultaneously

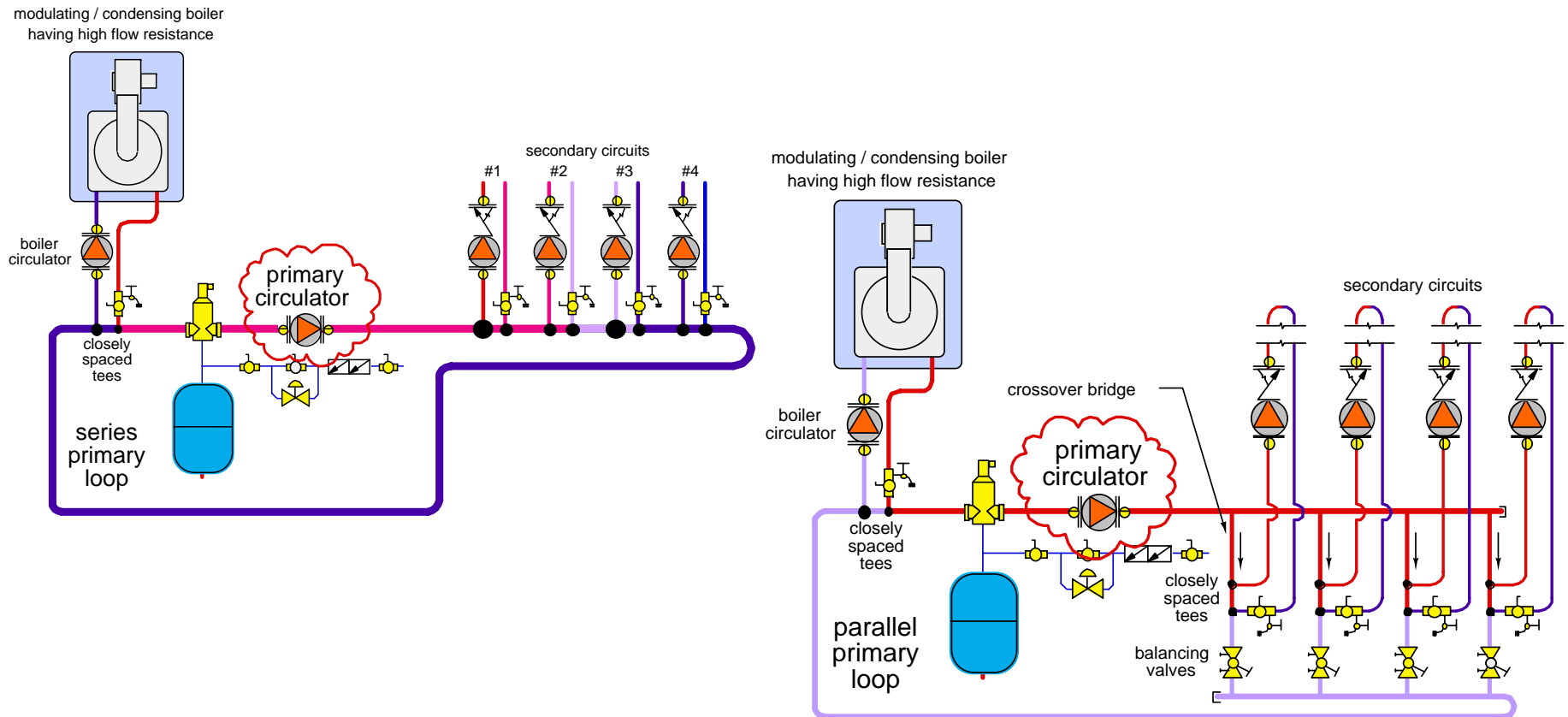


A **parallel** primary/secondary piping configuration provides the same water temperature to each secondary circuit:



This benefit is achieved at the expense of more complicated and costly piping.

In addition, both ***series*** and ***parallel*** primary/secondary systems require a primary circulator.



This adds to the installed cost of the system **AND** add **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:

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

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

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

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

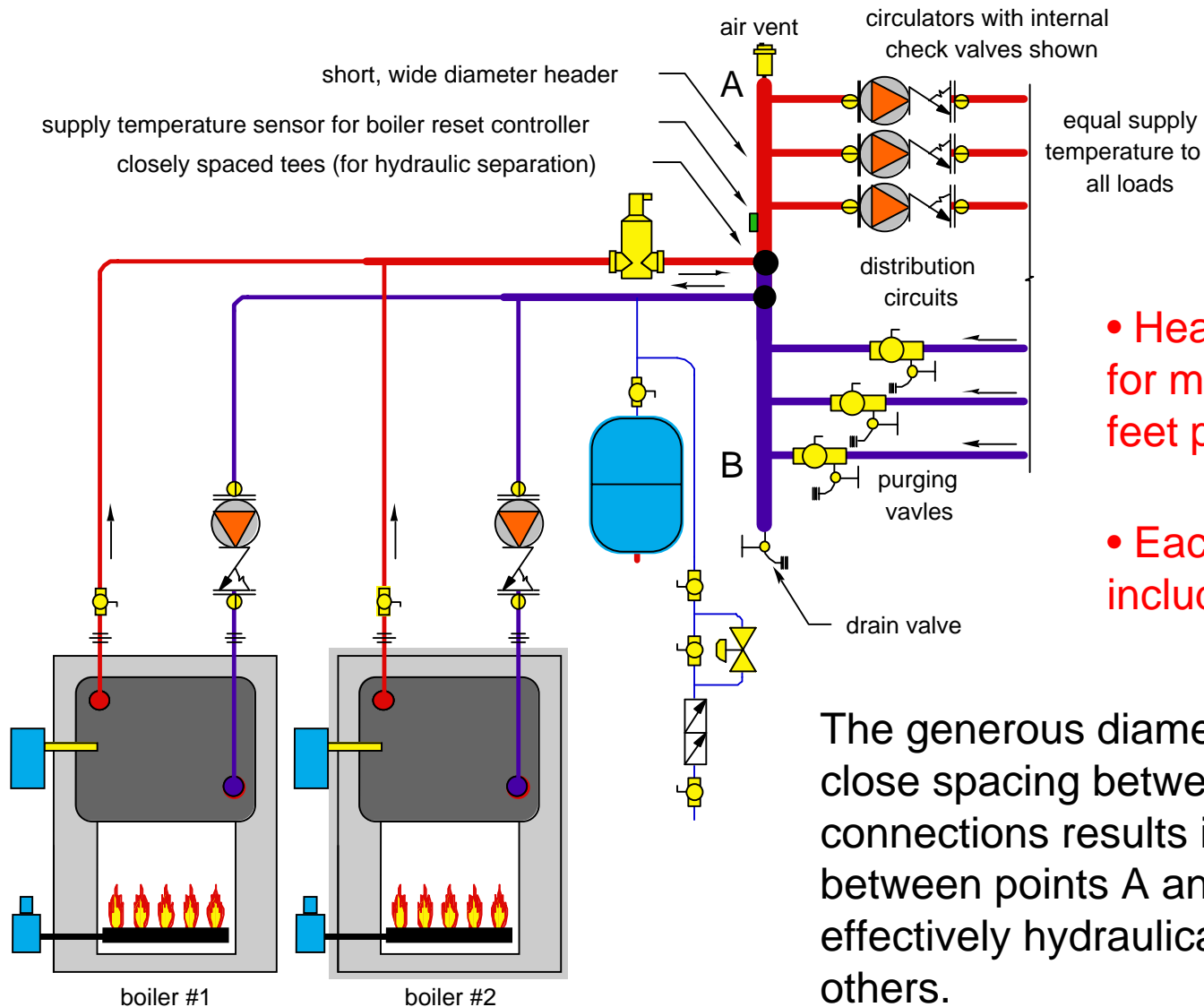
$$c_T = c_1 \times \left(\frac{(1+i)^N - 1}{i} \right) = \$165.60 \times \left(\frac{(1+0.04)^{20} - 1}{0.04} \right) = \$4,931$$

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

Beyond Primary / Secondary Piping...

How is it possible to achieve the **benefits** of hydraulic separation and equal supply temperatures **without** the **complexities** and **costs** of a parallel system and primary circulator?

Some systems begin and end individual load circuits in the mechanical room:

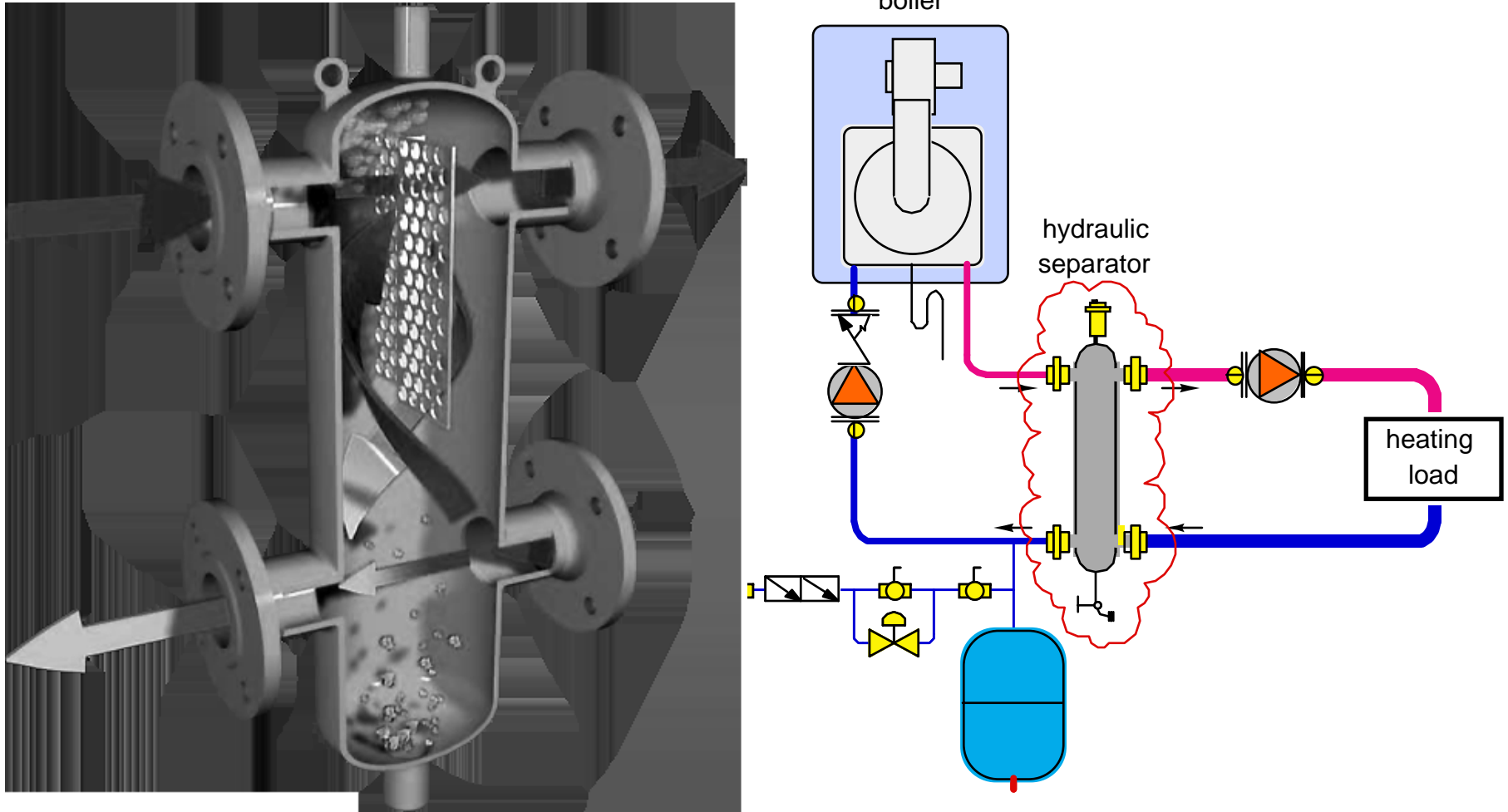


- Header should be sized for max. flow velocity of 2 feet per second

- Each circuit must include a check valve.

The generous diameter of the header and close spacing between supply and return connections results in a low pressure drop between points A and B. Each load circuit is effectively hydraulically separated from the others.

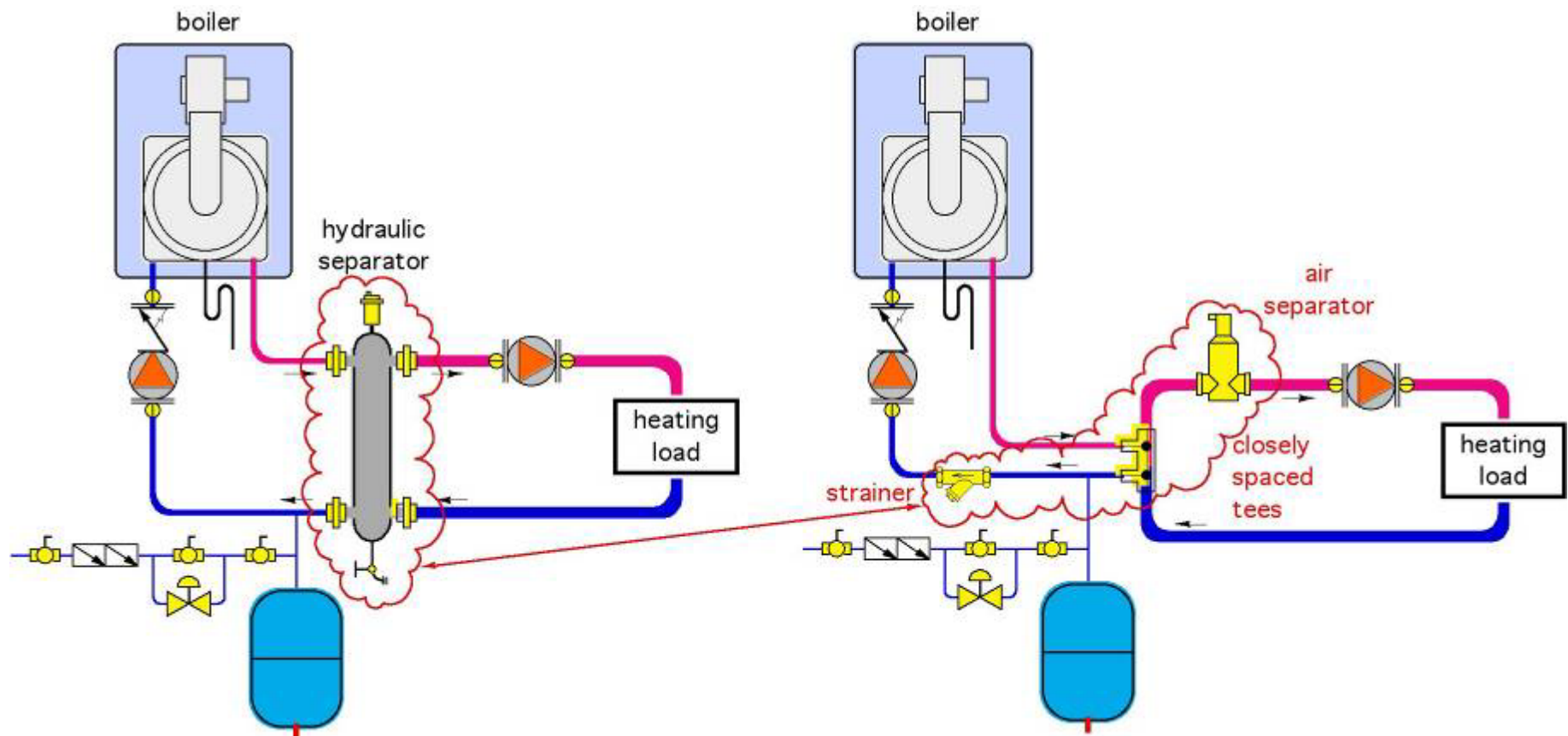
Another option is a specialized component called a **hydraulic separator** between the boiler and the load circuit:



The low vertical velocity inside the separator produces minimal pressure drop top to bottom and side to side. This results in **hydraulic separation** between the boiler circuits and load circuits.

Some hydraulic separators also provide air separation and sediment separation.

To achieve these functions in a system using closely spaced tees additional components are required:

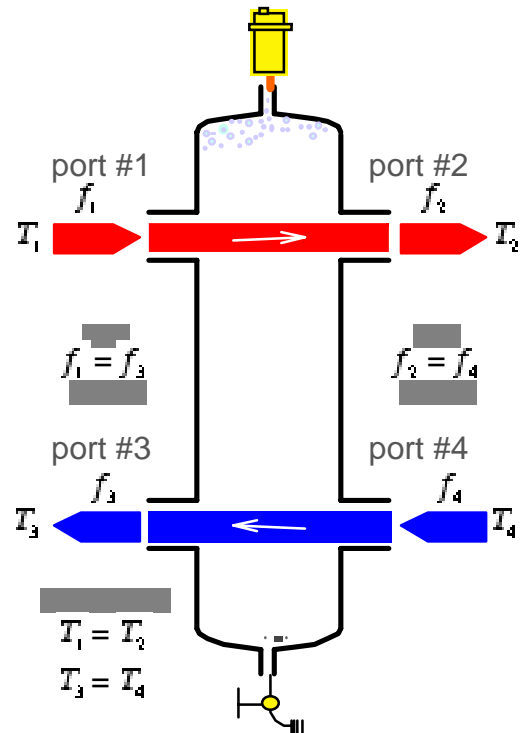


As the flow rates of the boiler circuit and distribution system change there are three possible scenarios:

- Flow in the distribution system is **equal** to the flow in the boiler circuit.
- Flow in the distribution system is **greater than** flow in the boiler circuit.
- Flow in the distribution system is **less than flow** in the boiler circuit.

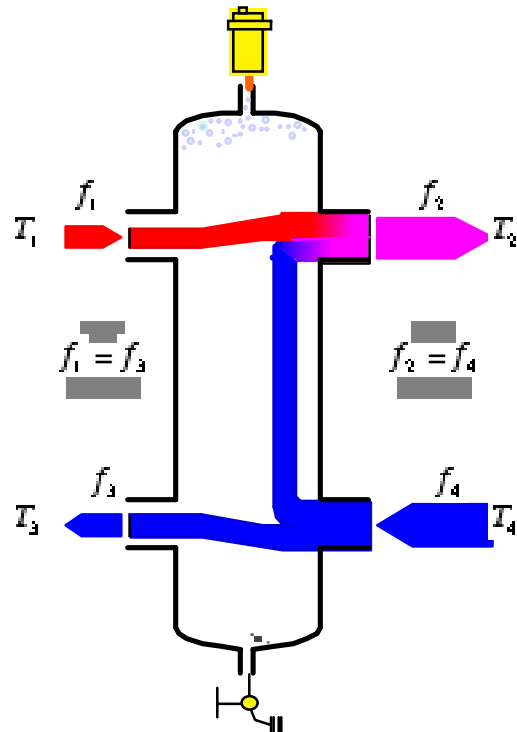
Each case is governed by basic thermodynamic...

Case #1: Distribution flow equals boiler flow:



Very little mixing occurs because the flows are balanced.

Case #2: Distribution flow is greater than boiler flow:



The mixed temperature (T_2) supplied to the distribution system can be calculated with:

$$T_2 = \left(\frac{(f_4 - f_1)T_4 + (f_1)T_1}{f_4} \right)$$

Where:

f_4 = flow rate returning from distribution system (gpm)

f_1 = flow rate entering from boiler(s) (gpm)

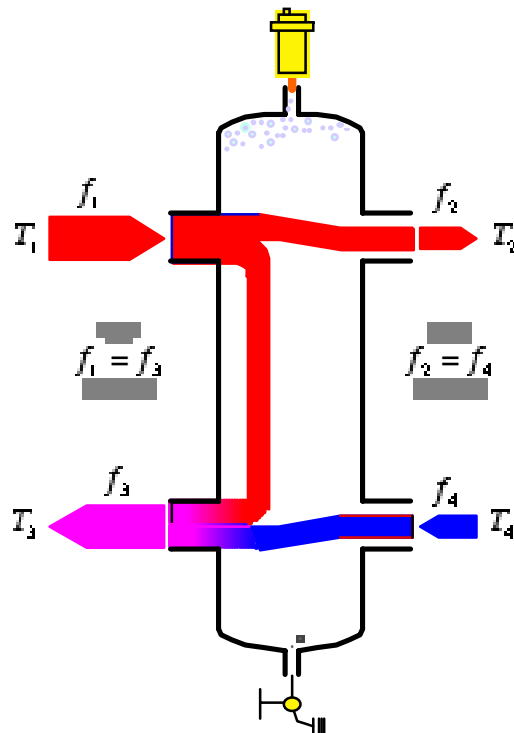
T_4 = temperature of fluid returning from distribution system (°F)

T_1 = temperature of fluid entering from boiler (°F)

Mixing occurs within the hydraulic separator.

Case #3: Distribution flow is less than boiler flow:

Heat output is temporarily higher than current system load.



Heat is being injected faster than the load is removing heat.

The temperature returning to the boiler (T_3) can be calculated with:

$$T_3 = \left(\frac{(f_4 - f_1)T_4 + (f_1)T_1}{f_4} \right)$$

Where:

T_3 = temperature of fluid returned to boiler(s) (°F)

f_1 = flow rate entering from boiler(s) (gpm)

f_2, f_4 = flow rate of distribution system (gpm)

T_1 = temperature of fluid entering from boiler (°F)

T_4 = temperature of fluid returning from distribution system (°F)

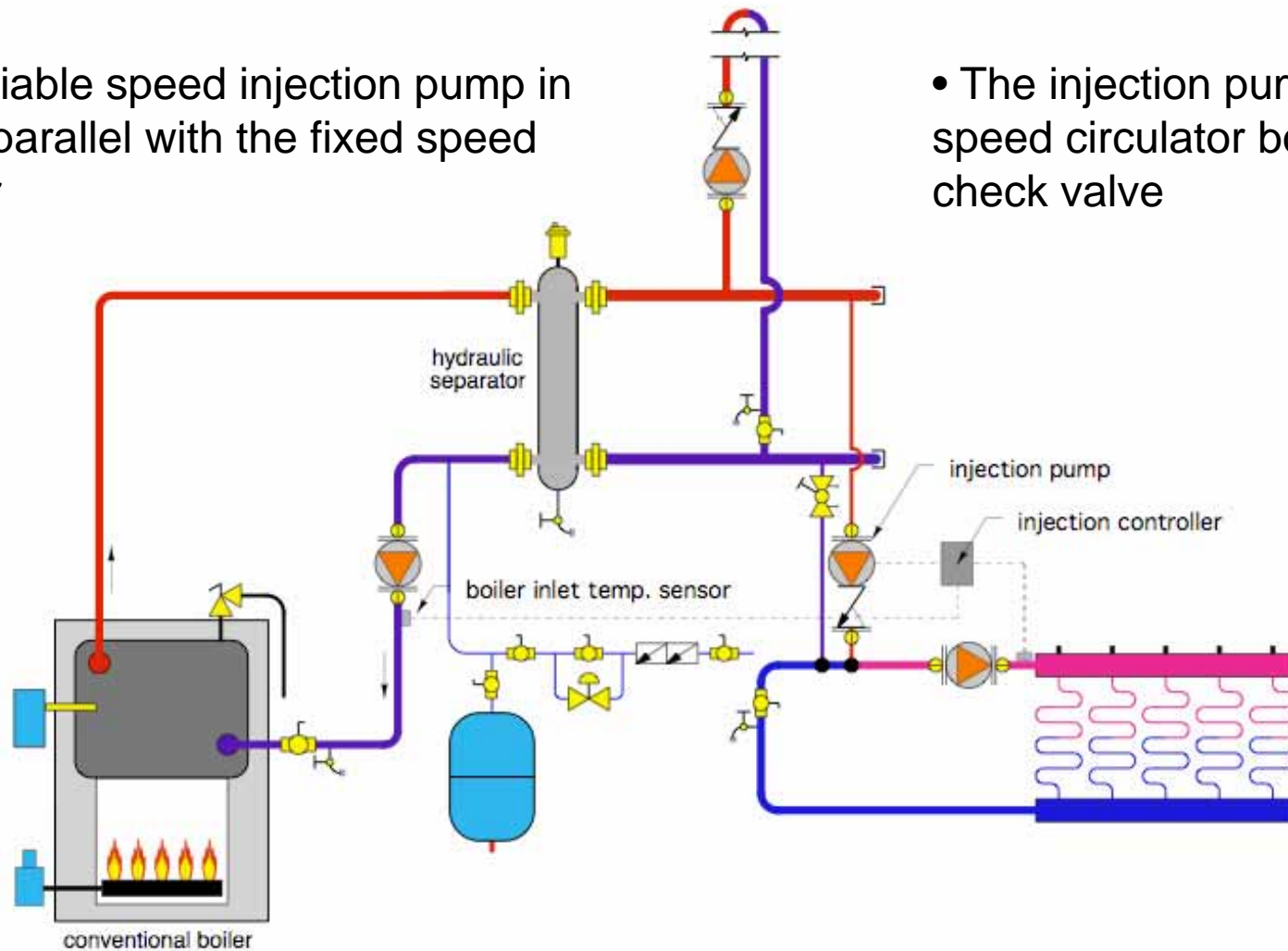
Mixing occurs within the hydraulic separator.

Use of a hydraulic separator alone does not prevent flue gas condensation under all circumstances.

To ensure such protection automatic mixing devices can be installed:

- The variable speed injection pump is piped in parallel with the fixed speed circulator

- The injection pump and fixed speed circulator both require a check valve



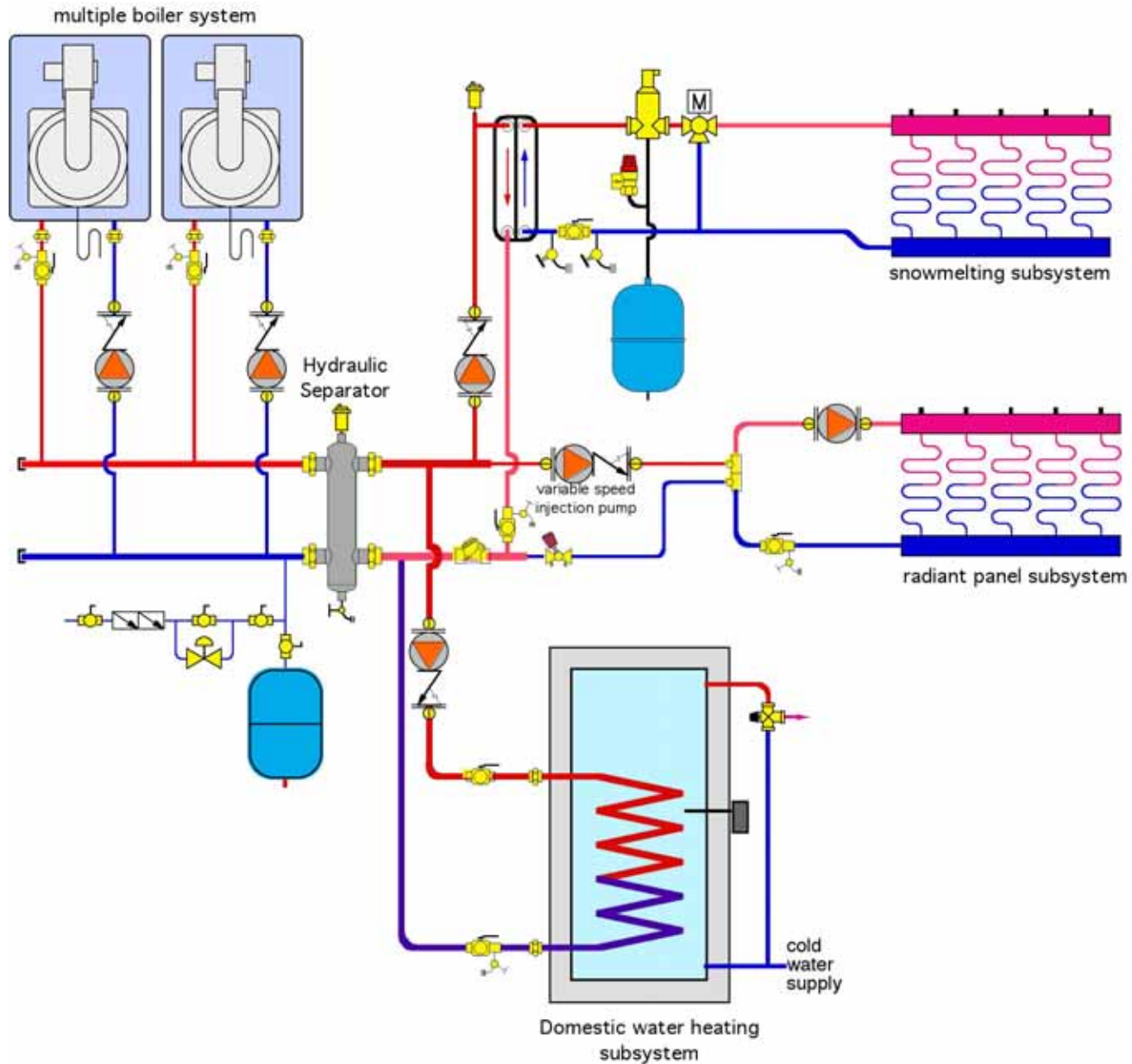
Sizing & Application:

Hydraulic separators **must be properly sized** to provide proper hydraulic, air, and dirt separation. Excessively high flow rates will impede these functions.

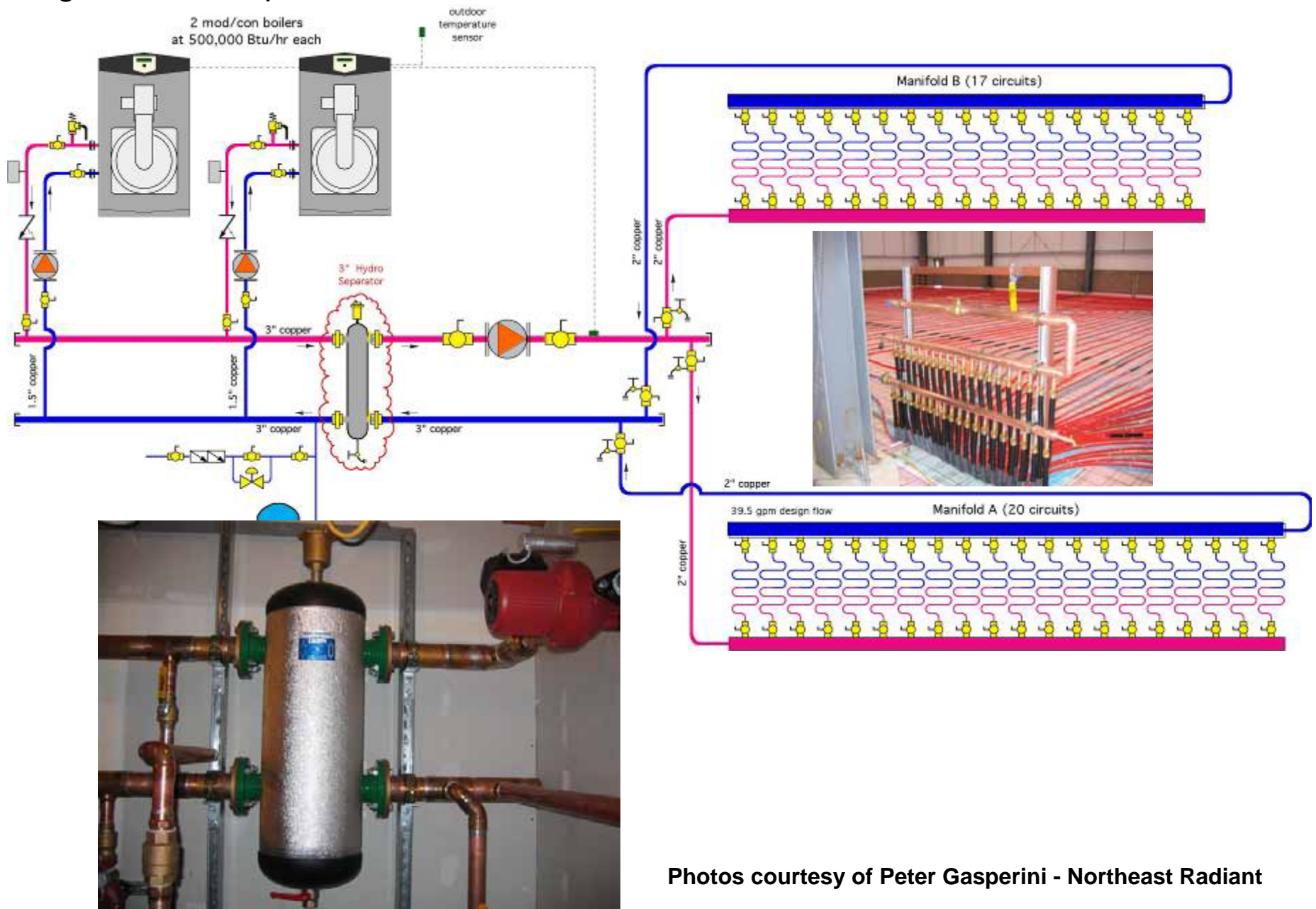
Pipe size of hydraulic separator	1"	1.25"	1.5"	2"	2.5"	3"	4"	6"
Max flow rate (GPM)	11	18	26	40	80	124	247	485

The header piping connecting to the distribution side of the Hydro Separator should be sized for a flow of 4 feet per second or less under maximum flow rate conditions.

Hydraulic separators are an ideal way to interface multiple loads to a Multiple boiler system.



Example of Hydro Separator Installation in New System: Magna Steel Corporation - Connecticut



Photos courtesy of Peter Gasperini - Northeast Radiant

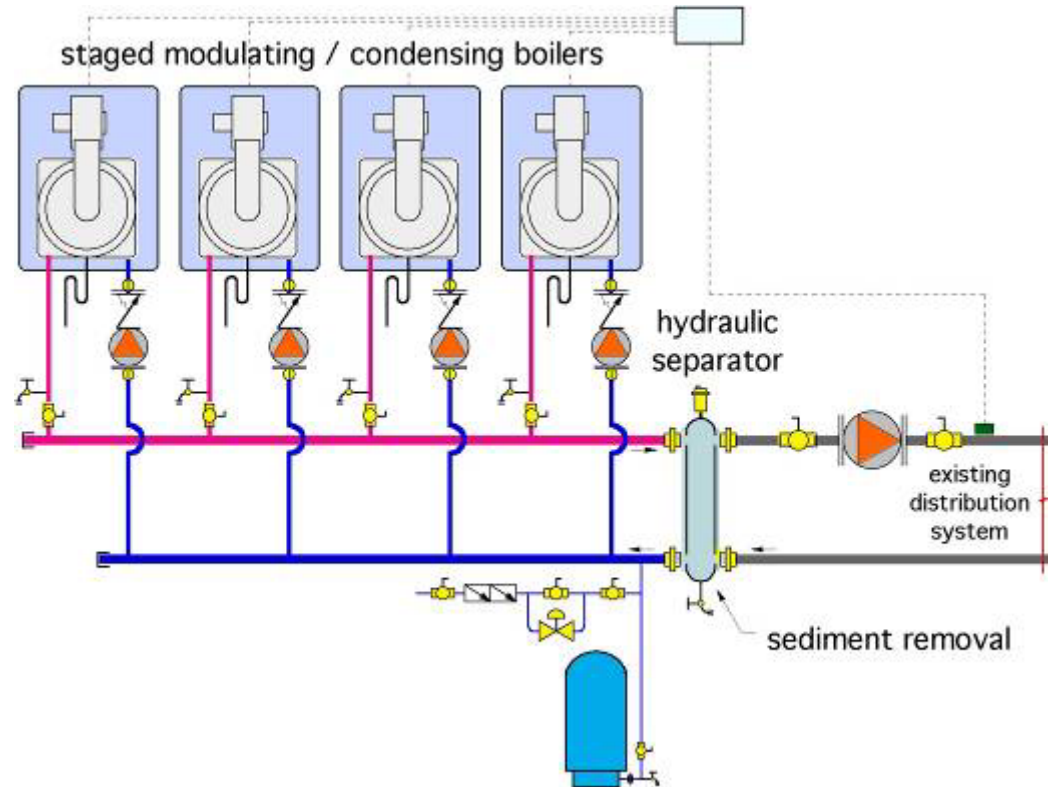
Example of Hydro Separator Installation in Old System:

Because hydraulic separators remove sediment from systems they're ideal for applications where new boilers are retrofit to old distribution systems.



Example of Hydro Separator Installation in Old System:

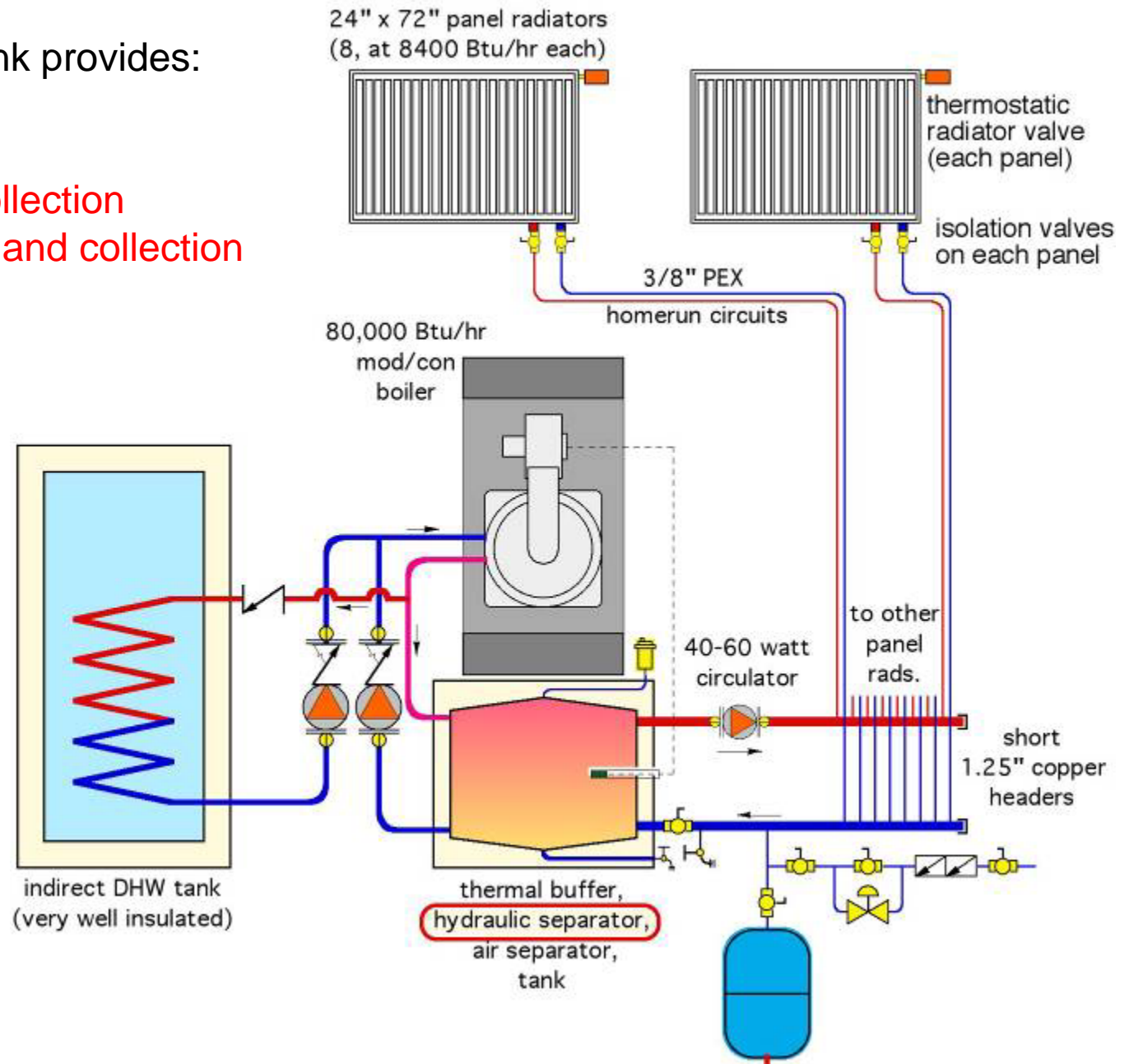
Here is how the previous system was retrofitted.



Hydraulic Separation in “Micro-load” systems:

The small insulated tank provides:

- Thermal buffering
- Hydraulic separation
- Air separation and collection
- Sediment separation and collection



Summary:

- Hydraulic separation, when properly executed, allows multiple, independently controlled circulators to coexist in a system without interference.
- These devices eliminate the need for a primary loop circulator, which reduces system installation and operating cost.

