EFFECTIVE: March 1, 2004 SUPERSEDES: New

OVERVIEW

Variable Speed Injection Circulators

Variable Speed Injection Mixing uses a circulator as a mixing device instead of a 2-way, 3-way or 4-way valve. Typically used in radiant primary/secondary piping designs, the variable speed pump is installed in the "bridge" piping (see Figure 1) between the boiler loop and system loop. The speed of the circulator is modulated in order to inject different rates of hot water from the boiler loop into the cooler system return water based on the relationship between outdoor temperature and supply water temperature (reset ratio). This configuration allows for virtually any water temperature to be supplied to the heating system. With outdoor mixing reset, the water temperature supplied to the heating zones can be reduced all the way down to room air temperature (full reset) even when a non-condensing boiler is being used. This allows for optimal control of the heating zone, no matter the load requirements. Most boilers cannot operate at low temperatures, therefore any Taco injection pump option can be modulated back in order to prevent the boiler from operating at cold temperatures.

Variable speed injection mixing can be achieved by using any standard "00" circulator along with a Taco PC705 Variable Speed Injection Mixing Control. Going one step further, the 00-VR Variable Speed Outdoor Reset "00" Circulator puts the entire injection mixing control right on board any model "00" circulator. All power and sensor wiring is done directly to the circulator, eliminating the need for an external control. The ultimate solution is the Radiant Mixing Block (RMB) which conbines a variable speed injection mixing control, injection circulator, system circulator, and air elimination into a single unit.

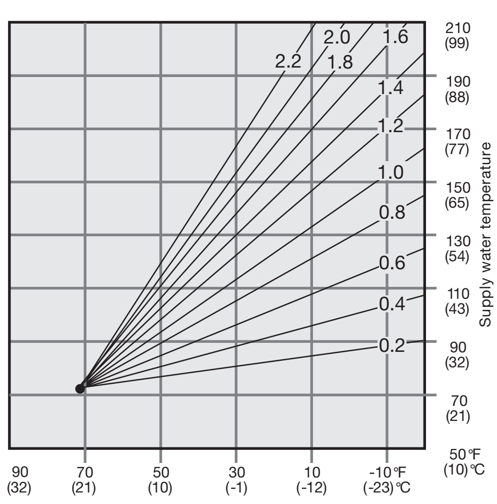
CONTROL STRATEGY

Outdoor Reset

In order to properly control a hot water heating system, the heat supplied to the building must equal the heat lost by the building.

- The heat supplied to the building is directly proportional to the temperature of the water and the surface area of the heating element. The higher the temperature of the water flowing through the heating terminal, the higher the heat output.
- The heat lost from a building is dependent on the outdoor temperature. As the outdoor temperature drops, the building heat loss increases.

These two facts lead to the concept of outdoor reset, based on a reset ratio, which increases the supply water temperature as the outdoor temperature drops. Using this approach, the heat lost from the building is matched by the heat provided by the terminal units, therefore providing more comfort and energy savings.



Benefits:

- **Uses "standard" 00 Circulators**
- **Full reset of heating zones**
- **Increased flow (heat transfer)**
- **Precise temperature control**
- **Less fluctuation of indoor temperatures**
- **Fully programmable**
- **Boiler protection**
- **Solid state microprocessor designed electronics available as an external control or integrated into a 00-VR circulator and Radiant Mixing Block**

Products:

PC705 – Variable Speed Injection Mixing Control
00-VR – Variable Speed Outdoor Reset "00" Circulator (available in all models of 003-0014)
RMB-1 – Radiant Mixing Block

Reset Ratio

The Reset Ratio sets the relationship between outdoor temperature and supply water temperature. It determines the amount the supply water temperature is raised for every 1 degree outdoor temperature drop. For example, if a Reset Ratio of 1.2 is selected, the supply water temperature is increased by 1.2 degrees of every 1 degree of outdoor temperature drop.

DESIGN

In order to properly accomplish this mixing method, the following piping details should be considered.

When the injection pump is turned off, there must be no heat transfer from the boiler loop to the system loop. In order to avoid this unwanted heat transfer, primary/secondary piping techniques are used as shown in Figure 1.

This piping arrangement requires that the injection piping be at least one pipe diameter smaller than the piping of the boiler and system loops. There must be no more than 4 pipe diameters between the tees in the boiler and system loops (Note 1), in order to prevent ghost flow when the injection pump is off and the system or boiler pump is on. Also, there must be at least 6 pipe diameters of straight pipe on either side of the tees (Note 2), in order to prevent the momentum of water from the boiler and system loops from pushing flow through the injection loop. Finally, there should be a minimum of 1 foot drop in the injection loop in order to create a thermal trap (Note 3) in order to prevent convective heat transfer through the injection loop.

The Radiant Mixing Block (RMB) eliminates the need for the piping technique as shown in Figure 1.

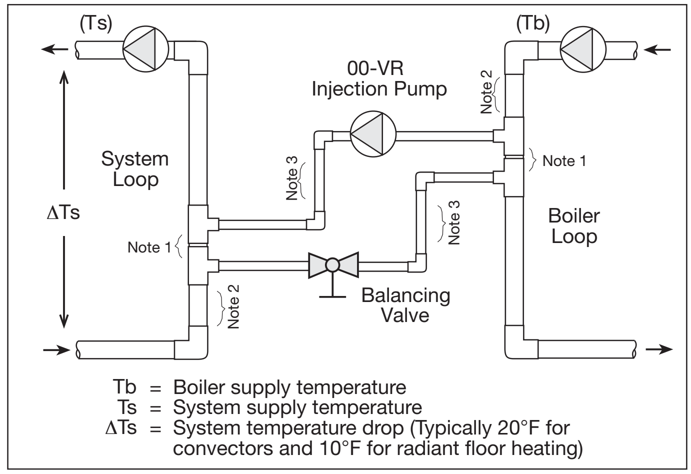


Figure 1

PUMP SIZING AND SELECTION

In order to properly size the pump, follow the design procedure below:

1. Determine the design operating temperatures of the system loop and boiler. (Ts and Tb from figure 1)
2. Determine the flow rate and design temperature drop (ΔT - Delta T) in the system loop. If one of these variables is unknown use Equation 1 or 2 to calculate the other variable.
3. Compute Tb - Ts. Look up the flow ratios in Figure 2.
4. The design injection flow rate for direct injection is calculated from Equation 3. If the injection flow rate is greater than 40 US GPM, a 3-way or 4-way valve may be required.
5. Decide whether or not to include a balancing valve in the injection piping. A balancing valve allows adjustment when the injection pump is larger than needed. A balancing valve also provides the possibility of manual operation of the system by turning the injection pump fully on and adjusting the balancing valve to obtain the desired supply water temperature.
6. The injection piping size and model of Taco 00 pump to install can now be looked up in Figure 3. Do not oversize the injection system. If the injection system is not able to provide enough heat, the boiler's aquastat may be increased.

$$\text{Eq. 1: System Flow Rate (US GPM)} = \frac{\text{Design Heating Load (BTU/hr)}}{500 \times \Delta\text{Ts} \ (°\text{F})}$$

$$\text{Eq. 2: } \Delta\text{Ts} \ (°\text{F}) = \frac{\text{Design Heating Load (BTU/hr)}}{500 \times \text{System Flow Rate (US GPM)}}$$

$$\text{Eq. 3: Design Injection Flow Rate (US GPM)} = \text{System Flow Rate (US GPM)} \times \text{Flow Ratio}$$

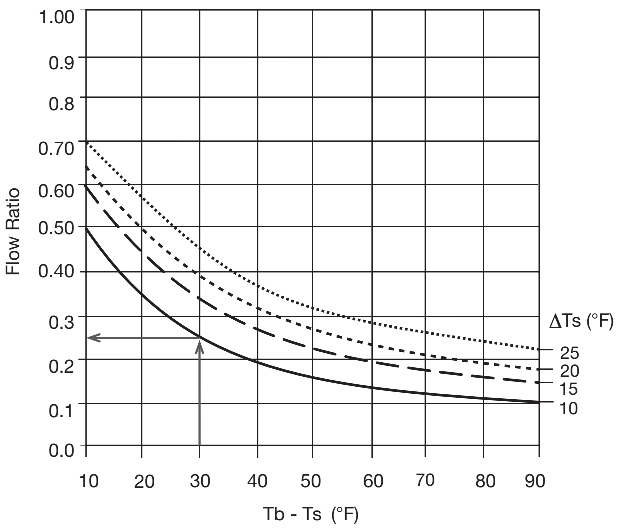


Figure 2

Design Injection Flow Rate (US GPM)	Balancing Valve Position (% open)	Balancing Valve Cv	Nominal Pipe Diameter (inches)	TACO Pump
1.5	30	2.4	0.5	003
2	40	4.5	0.5	003
3	40	4.5	0.5	006
4	100	15	0.5	006
7	40	6.9	0.75	007
8	50	10.4	0.75	007
9	30	5.76	1	007
12	40	10.8	1	007
14	40	10.8	1	0010
16	100	36	1	0010
20	50	19.8	1.25	0010
25	50	28.8	1.5	0010
30	30	18.2	2	0012
40	40	34.2	2	0012

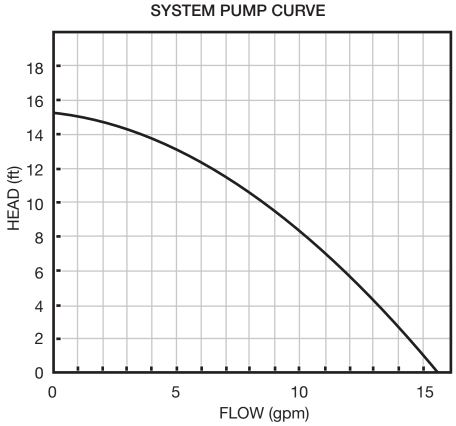
This table assumes there are 5 feet of pipe, 4 elbows, and 4 branch tees of the listed diameter. Balancing valve is assumed to be a ball valve. The approximate Cv value is provided in order to allow for proper balancing device. Valve characteristics may vary for the same size and type of ball valve from manufacturer to manufacturer.

Figure 3

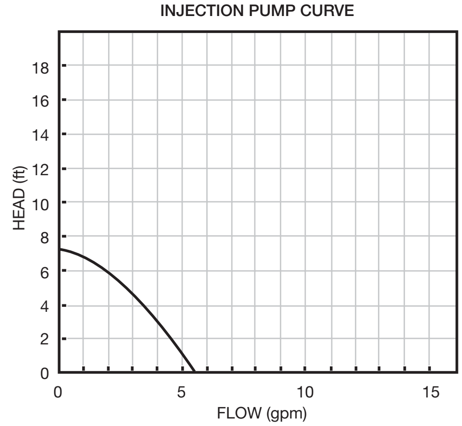
In order to ensure proper selection of the Radiant Mixing Block, follow the design procedure below:

1. Using the pump curve located below, ensure that the System Pump of the Radiant Mixing Block will provide adequate flow for the system in which it is to be installed.
2. Using the table or equation below, determine the required flow rate for the Injection Pump.
3. Using the pump curve located below, ensure that the Injection Pump of the Radiant Mixing Block will provide adequate flow for the system in which it is to be installed.

SYSTEM PUMP CURVE



INJECTION PUMP CURVE



Required Injection Pump Flow Rate

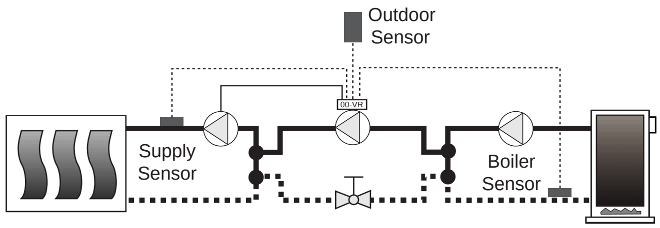
Tb = Boiler Supply Temperature
Ts = Radiant Supply Temperature

Eq. 4: Injection Flow Rate (GPM) = $\frac{\text{BTU's}}{(Tb - Ts) \times 500}$

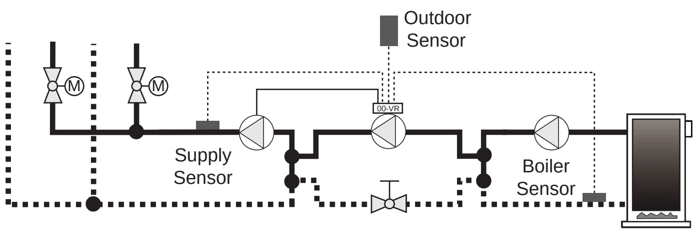
Required Injection Flow Rate (GPM)

Tb - Ts	BTU's x 1000					
	20	40	60	80	100	120
100	0.4	0.8	1.2	1.6	2.0	2.4
80	0.5	1.0	1.5	2.0	2.5	3.0
60	0.7	1.3	2.0	2.7	3.3	4.0
40	1.0	2.0	3.0	4.0	5.0	
20	2.0	4.0				

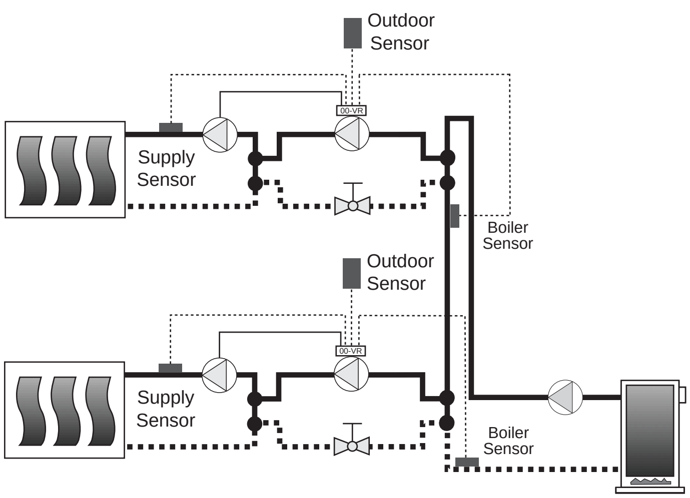
00-VR or PC705 with Standard “00” Circulator



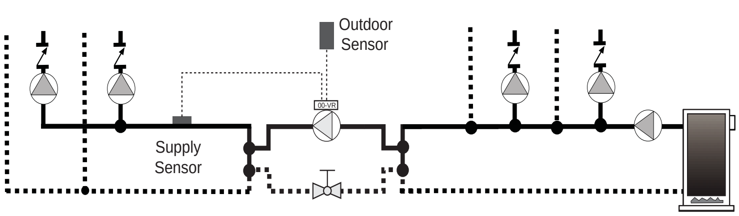
Variable Speed Injection Mixing



Variable Speed Injection Mixing with Low Temperature Zones

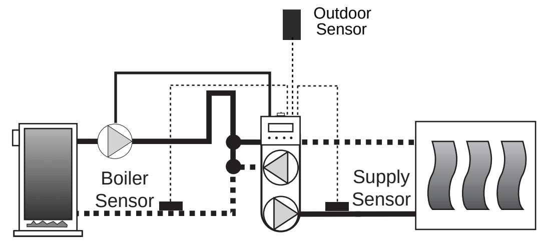


Variable Speed Injection Mixing

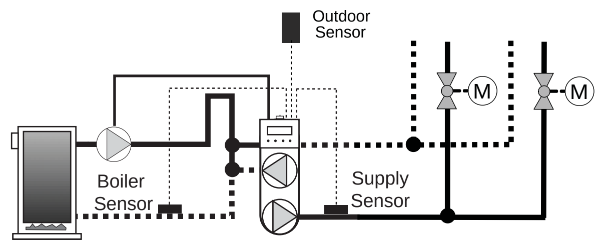


Multiple Temperature System

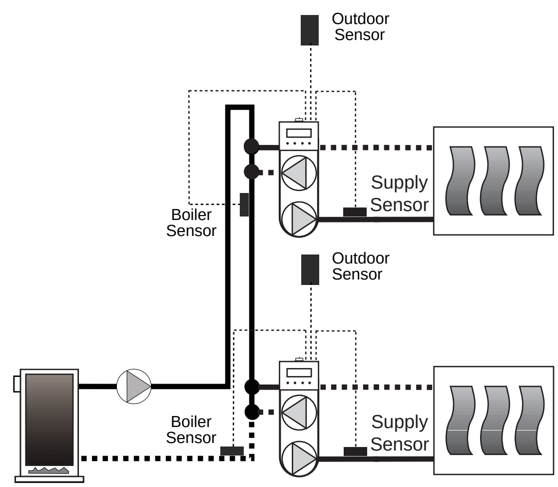
Radiant Mixing Block (RMB)



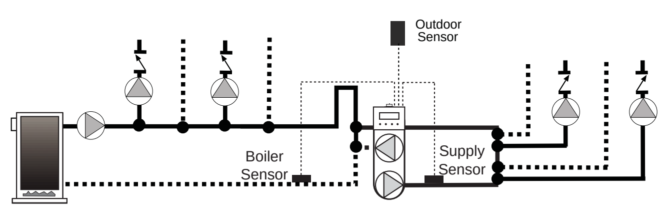
RMB - Radiant Mixing Block



RMB - Radiant Mixing Block, Multiple Zone Valves



RMB - Multiple Radiant Mixing Blocks



RMB - Radiant Mixing Block, Multiple Temperature System

For installations where boiler protection is **NOT** required, the boiler sensor does not need to be installed.
For additional installation diagrams, refer to the appropriate product’s Products & Application documentation.

Radiant Made Easy™

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