PC705 Variable Speed Injection Mixing Control

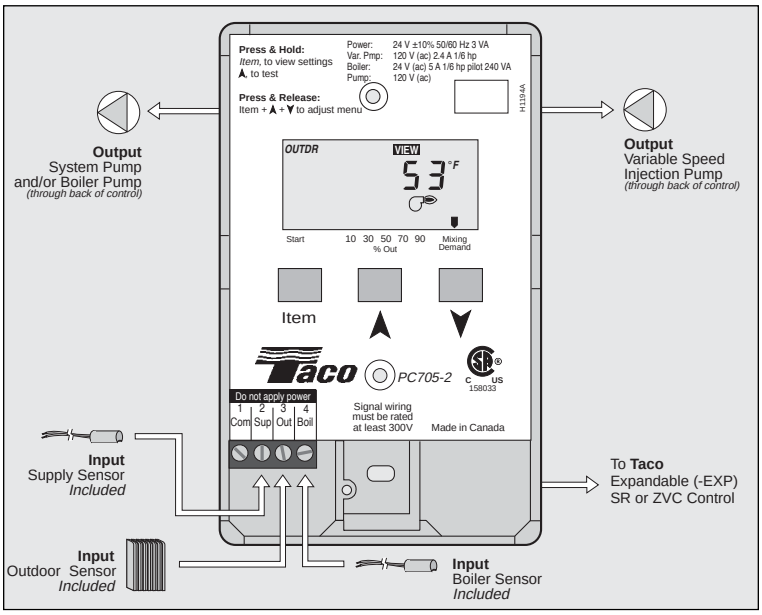
EFFECTIVE: March 1, 2004

SUPERSEDES: New

OVERVIEW

PC705: Variable Speed Pump Injection Mixing Control

The Taco Mixing Control regulates the supply water temperature to a heating system by simultaneously controlling a boiler and the speed of an injection pump. Based on the outdoor air temperature, the PC705 continuously adjusts the boiler differential to optimize the firing cycles of the boiler, prevent large water temperature swings, and increase the efficiency of the system. As the heating load increases, the Mixing Control speeds up the injection circulator and as the load decreases, it slows down the injection circulator. The PC705 has a liquid crystal display that clearly shows the speed of the variable speed injection pump. It also features warm weather shutdown, a maximum supply water temperature setting, and a boiler sensor that can be connected in order to prevent corrosion in the boiler due to flue gas condensation.



CONTROL STRATEGY

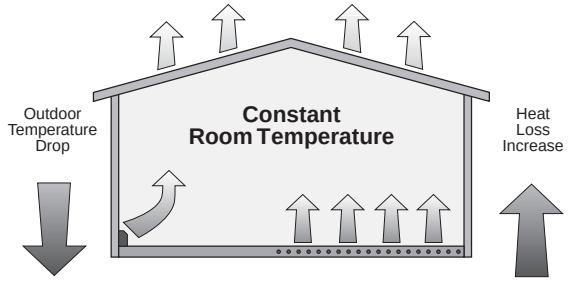
Outdoor Reset

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.



Reset Ratio

Operation of a hot water heating system can generally be improved by modulating the supply water temperature as the outdoor temperature changes. Using this approach, the heat lost from the building is matched by the heat input to the building. The PC705 Boiler Reset Control utilizes a reset ratio to set the relationship between outdoor temperature and supply water temperature. The reset ratio determines the amount the supply water temperature is raised for every 1° drop in outdoor air temperature, and it is determined from the starting point and the system design conditions. In order for the control to automatically determine the reset ratio, a starting point and design conditions must be established. These two points are set by the following 4 adjustments:

Features:

- **Regulates supply water temperature by controlling a boiler and the speed of an injection pump**
- **Microprocessor PID Control**
- **Plugs into any Taco Expandable (-EXP) Switching Relay or -EXP Zone Valve Control**
- **Controls up to 5 Amp 1/6 HP pumps**
- **Boiler protection**
- **Automatic reset ratio calculation**
- **Warm weather shut down (WWSD)**
- **Max supply water setting**
- **System pump relay**
- **Sensors included**

Outdoor Starting Temperature (OUTDR START)

The Outdoor Starting Temperature is the outdoor air temperature at which the Boiler Starting Temperature is supplied. This setting is typically set to the desired building temperature.

Boiler Starting Temperature (BOIL START)

The Boiler Starting Temperature is the starting supply water temperature required to maintain the building interior at the design indoor temperature when the outdoor air temperature is the same as the Outdoor Starting Temperature.

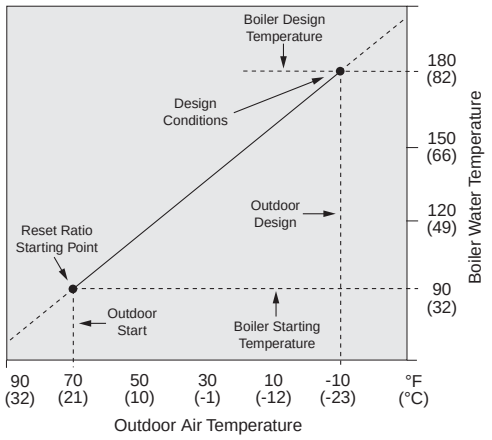
Outdoor Design Temperature (OUTDR DSGN)

The Outdoor Design Temperature is the outdoor air temperature that is the typical coldest day of the year where the building is located. This temperature is used when doing the heat loss calculations for the building.

Boiler Design Temperature (BOIL DSGN)

The Boiler Design setting is the supply water temperature required to satisfy the building's heat loss during the coldest outdoor temperature. This adjustment is typically dependent on the type of heating terminal used.

Once these two points have been determined, the system supply temperature is varied based on a straight line between these two points.

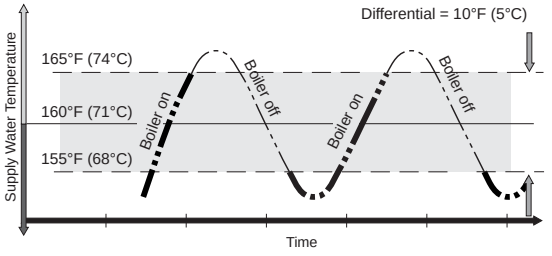


BOILER OPERATION THEORY

The supply water temperature from a boiler can be controlled by cycling the boiler on and off. Modulation of the boiler's operating temperature in hot water heating systems not only provides more comfort but also offers significant energy savings. The cooler the boiler runs, the more efficient it is due to less heat losses up the flue and reduced boiler jacket losses.

Differential

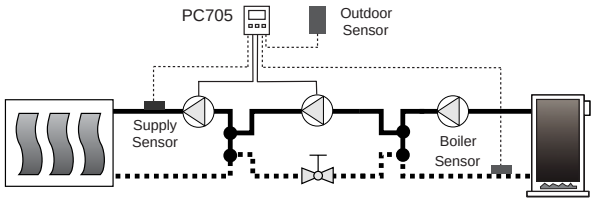
An on/off boiler must be operated with a differential in order to prevent short cycling. When the supply water temperature drops below the bottom rail of the differential, the boiler is turned on. The boiler is then kept on until the supply water temperature rises above the top rail of the differential. If the differential is too wide, there can be large supply water temperature swings; however, if the differential is too narrow, the boiler short cycles and operates inefficiently. These controls are either manually set or can automatically calculate the boiler differential in order to achieve an appropriate balance between temperature swings and boiler efficiency. This also permits the control to adapt to changing loads and conditions. The control includes a minimum on and off time for the heat source(s), in order to minimize short cycling.



Boiler Sensor Installed

While the PC705-2 has a mixing demand, the boiler supply water temperature is controlled by turning the boiler on and off. The PC705-2 calculates the required boiler supply water temperature based on the load on the mixing system.

The boiler operates around a differential that is automatically controlled by the PC705-2. The control includes a minimum on and off time for the heat source, in order to minimize short cycling. The automatic boiler differential increases system efficiency by adjusting to changing loads.



Variable Speed Injection Mixing

Boiler Sensor Not Installed

When the PC705-2 has a mixing demand, the boiler turns on and operates off the boiler operating aquastat. The Mode switch on the Zone Control must be set to Normal in this application. To improve boiler operation efficiency, the boiler design temperature should be selected as low as possible, and the injection pump, must then be sized accordingly.

Boiler Protection

When the boiler sensor is installed on the supply side of the boiler the PC705-2 can protect the boiler against flue gas condensation. When this sensor is installed, the PC705-2 ensures a boiler supply water temperature of at least the Boiler Minimum setting. If the water temperature is less than the Boiler Minimum setting, the PC705-2 turns on the MIN segment in the LCD and decreases the speed of the injection pump.

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.

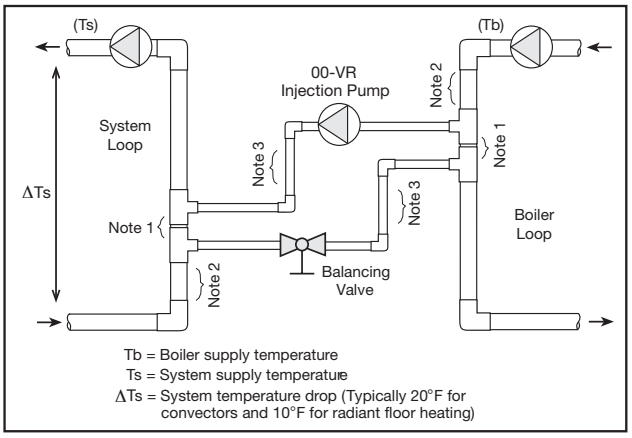


Figure 1

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.

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 determine the other variable.
3. Compute Tb - Ts. Look up the flow rates on Figure 2.
4) The design injection flow rate for direct injection is calculated in 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 pump size and model of Taco 00 pump to install can 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.

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

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

Eq. 3: Design Injection Flow Rate (US GPM) = System Flow Rate (US GPM) x Flow Ratio

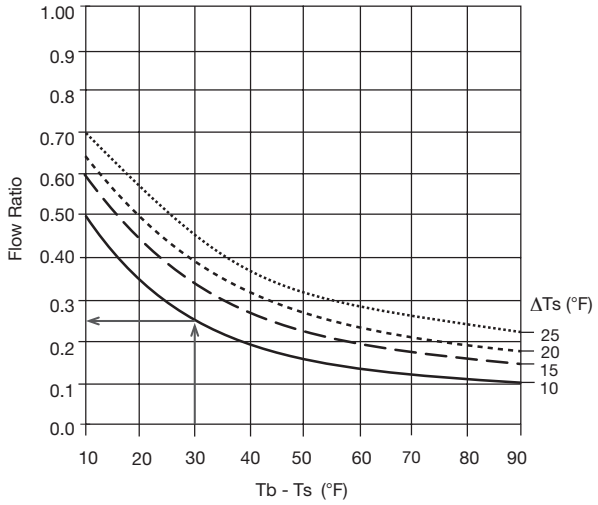


Figure 2

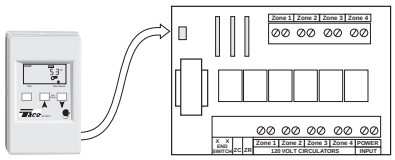
Design Injection Flow Rate (US GPM)	Balancing Valve Position (% open)	Balancing Valve Cv	Nominal Pipe Diameter (inches)	TACO Pump
1.5	30	2.4	0.5	003
2	40	4.5	0.5	003
3	40	4.5	0.5	006
4	100	15	0.5	006
7	40	6.9	0.75	007
8	50	10.4	0.75	007
9	30	5.76	1	007
12	40	10.8	1	007
14	40	10.8	1	0010
16	100	36	1	0010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

PC705-2 OPERATION

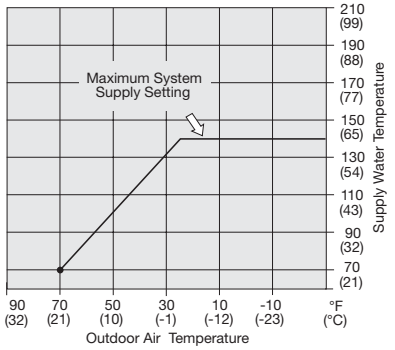
Mixing Demand



The PC705-2 obtains a mixing demand through the Taco Expandable Zone Control when a zone calls for heat.

Mixing Operation

The PC705-2 calculates the required supply water temperature based on the outdoor temperature. The supply water temperature is then controlled by varying the speed of an injection pump to maintain the target supply temperature. As the heating load increases, the PC705-2 speeds up the injection pump and as the load decreases, the PC705-2 slows down the injection pump. The bar graph in the bottom of the LCD indicates the speed of the variable speed injection.



Warm Weather Shut Down (WWSD)

When the outdoor temperature is warmer than the WWSD setting, the PC705-2 turns off the boiler and the variable speed injection pump. The PC705-2 has a freeze protection feature that does not allow the supply water temperature to drop below 35°F (2°C) as long as there is a mixing demand signal.

Maximum System Supply Temperature

The PC705-2 has a Maximum Supply setting that can be used to set a maximum system supply water temperature. If the supply water temperature approaches the Maximum Supply setting, the control reduces the speed of the injection pump.

SETPOINT OPERATION

The PC705 can operate as a setpoint control by setting the Mix Design to the same temperature as the Mix Start setting.

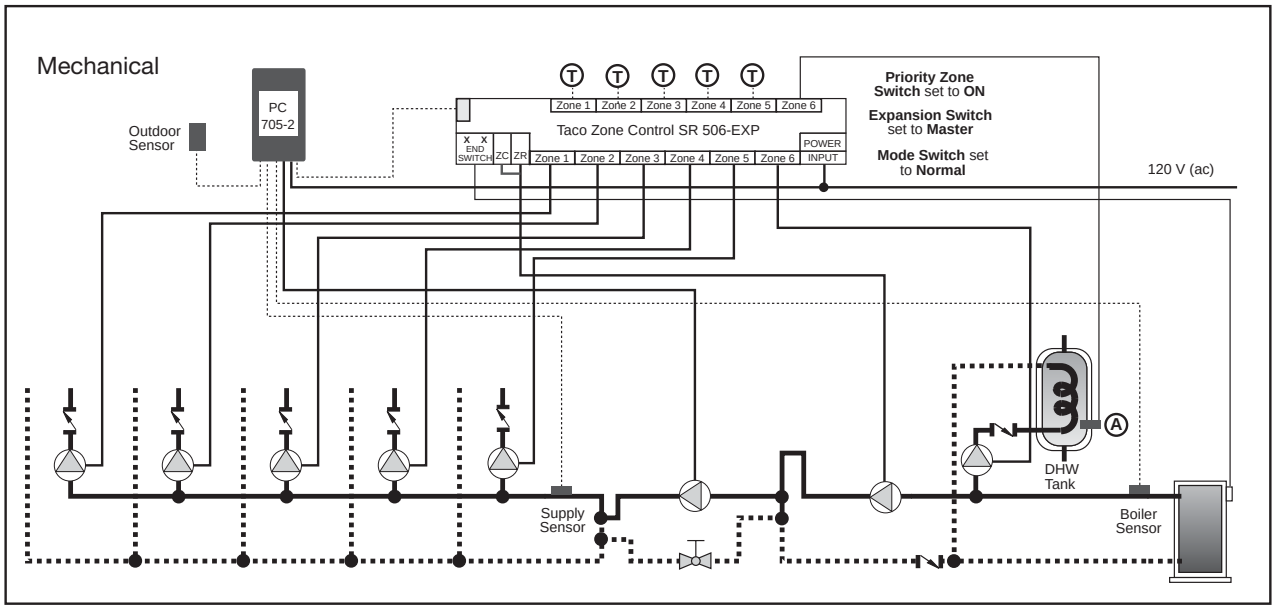
SYSTEM PUMP OPERATION

The PC705-2 has an internal system pump contact. This contact turns on when the PC705-2 has a mixing demand and is not in a WWSD.

The system pump as well as the boiler pump may be controlled by this relay. By providing proper flow in the boiler loop, the boiler temperature can be accurately controlled based on the mixing load.

INSTALLATION

Radiant Floor Heating with DHW



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