CGC's Bulldog System Loop Control

Overview

The CGC Group's **Bulldog FreeHeat** system does **NOT** operate with the same loop temperatures that are common to a traditional Water Source Heat Pump system. The Bulldog system differs from a WSHP system in that it does not operate the compressor for the heating mode. Instead each Bulldog includes a hot water heating coil that is activated to enable heating. In order for the heating coil to produce heat the system fluid temperature must be somewhat higher than the room temperature. As with most hydronic heating systems, the supply fluid temperatures are increased as the outside air temperatures drop.

In order to have available heat at all times in all zones, the FreeHeat loop temperature is maintained at 85°F (30°C) at ambients above 55°F; this will enable any unit to produce a minimum of 30% of its rated heating capacity. As outside air temperatures fall below 55°F (13°C) the loop temperatures are increased. The nominal rate of increase is .40 degree increase in loop temperature for every degree drop in ambient. As such the loop temperature will be 104°F (40°C) at 8°F (-13°C) outside.

One of the advantages of the Bulldog system is that the heating/cooling ratios can be tailored to the actual loads. To optimize the efficiency of the system the reset rate can be adjusted to follow loading. For example when the cooling requirements of each zone are much higher than the heating loads, the set point reset rate can range from .25 to .40 degree increase per degree drop in ambient. Then at 15°F ambient, the loop temperature would be less than 100°F. Similarly, installations such as a seniors residences where heating is the dominant load, the setpoint reset rate can be steeper, perhaps as high as .75 degrees per degree ambient drop. Additionally, the setpoint reset rate start point can be moved several degrees higher or lower to suit.

The CGC Group offers a prepackaged system controller that is programmed to accommodate most system arrangements. Custom sequences can be programmed into the panel. The CGC system controller has BACnet interface and can be integrated into most BAS systems provided by others.

Controls by Others

Should a third party control system be selected, it must be programmed to provide the functions as required by the system. These functions include maintaining both adequate flow rates and the scheduled loop temperatures. For reliable system operation we recommend the following algorithms be incorporated.

Pumping

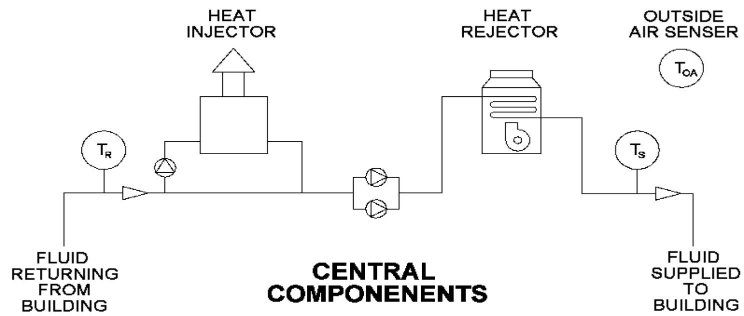
CGC strongly recommends that the system pumps have full standby. On smaller systems, CGC recommends that two pumps each sized to provide 100% flow be installed. On larger systems, a three pump arrangement each of 50% capacity be considered, with two operating at all times. With a two pump arrangement we recommend that one operate for the first ½ of the month, and the second be used for last half of the month. Similarly, on a three pump installation, each pump be shut down for a period of 10 days per month. On pump rotation allow a 10 second delay before starting up new pump.

Variable flow systems are common on most larger systems above 100 tons. Bulldog units are available with Demand flow which includes separate two way valves for the condenser and for the heating coil. Additionally, AutoFlow valves are recommended to maintain the design fluid flow thru the unit when operating. When ordered these valves are factory installed.

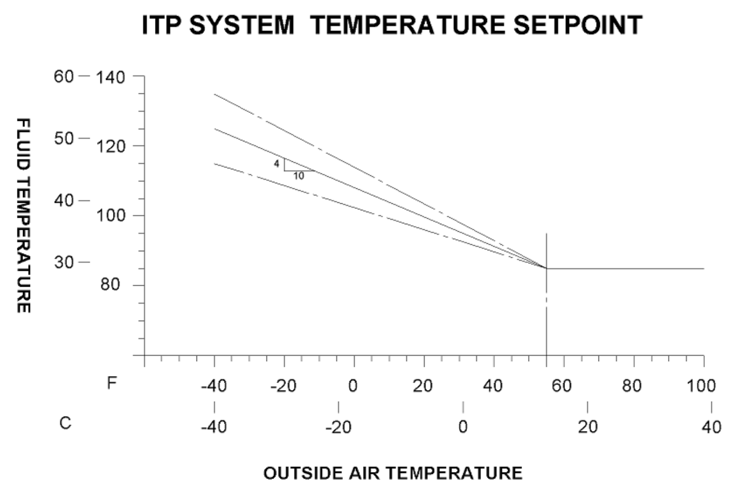
Pump controls on Variable Flow Systems must be carefully selected and controlled in order to ensure maximum energy efficiency and reliability. There can be savings in piping and pump sizing as these can be based on peak block load, and not the sum of installed unit flow rates as required with constant flow systems. This can result in pump sizing reductions in the range of 10% to 30%.

Control of the pump speed can be achieved either with a Sensorless Pump Control built into the pump manufacturers speed drive, or a built up system with appropriate sensing and control algorithms. Sensorless control must be set up by the pump manufacturer to provide design flow and head at full load conditions, and then 20 foot head at no flow. A built up system will require that a differential pressure sensor be installed to measure the differential pressure between the supply and return piping 2/3 of the distance from pumping station. The controller must then maintain a differential pressure at that point of approximately 25 feet.

Pump flow shall be monitored by the control panel. CGC recommends that Pressure Differential switches be utilized to provide flow monitoring rather than paddle type flow switches. PD switches are more reliable, do not require system drainage for repair, and are not affected by turbulent flow. On variable flow systems a differential switch is required. A two pump system will require one pressure differential switch installed across the supply and return headers. The three pump arrangement will require three pressure differential switches, which must be installed across each individual pump. The control panel shall command one or more pumps ON in accordance with the above schedule. However, should the flow monitor detect a flow failure that exceeds 15 seconds, the panel shall shut down the operating pump and immediately start up the standby pump. This pump shall be operated continuously whether or not the flow sensor is satisfied, until the algorithm is manually reset. Simultaneously a flow failure alarm shall be sounded.



Temperature Control (Set Point)
In order to optimize the performance of the FreeHeat system, the temperature of the fluids supplied to the units must be accurately controlled. CGC has developed a series of control algorithms that best satisfy the needs of the system. But first, three accurate temperature sensors are required. The outside air sensor must be mounted outdoors on a surface that is not ever exposed to the sun. This sensor must be located where it will not be influenced by heat transmission through the walls, by exhaust air streams, or nearby heat producing equipment. System return water and supply water sensors must be installed on the piping where they will not be compromised by cold outside air, boiler vents, unit heaters, etc. Sensors on the fluid lines should be insulated.



The **system set point** is similar to that for a hot water heating system with the following control points:

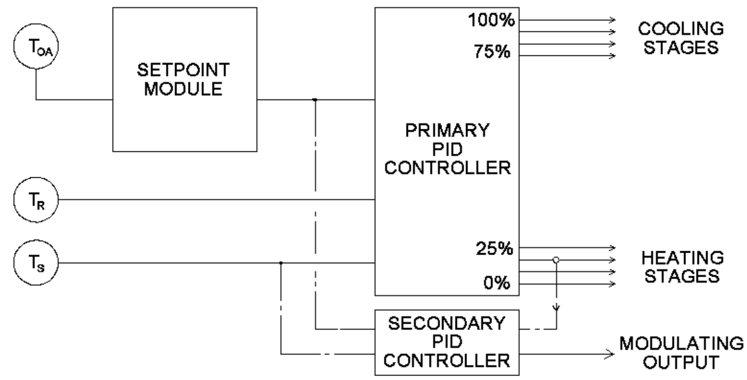
- 55°F(13°C) ambient and above - hold 85°F(30°C)
- below 55°F(13°C) ambient - 85°F(30°C) plus (55°F(13°C) minus ambient°F) times 'reset rate'
- Reset rate .25 to .75
- Maximum setpoint temperature 125°F(52°C)

The reset rate is adjusted to maximize performance with the lower rate increasing the cooling efficiency but reducing the heating capacity. Office buildings are satisfied with a reset rate of between .25 and .40. Schools .35 to .50, condos and hotels .40 to .60. Seniors residences .50 to .75. *Example: School with a .40 Reset Rate will have a loop setpoint of 107°F at 0°F ambient. 85+(55-0)x.40=107 (30°C+(13°C--18°C).40=42°C*

Temperature Control (Output)
It is common on WSHP systems to have coolers or boilers directly connected to the loop and staged on and off to maintain system temperatures. An example would be staging of lo-hi fired boilers to inject heat. Effective staged (stepped) control is difficult to achieve with control from discharge temperatures as excessive cycling of components is common. For this reason CGC recommends that for the hybrid system the staged controlled outputs be controlled from the return water temperature sensor in order to maintain system stability.

Modulating control functions for valves or modulating boilers etc. on the other hand are best controlled from a discharge fluid temperature sensor. It may be that both modes are required, a staged arrangement controlled via return water temperature, and an analog output to control a VFD on a heat rejector controlled from supply fluid temperatures.

The standard system control algorithms for stage unit control are PID based and arranged as follows:



- Primary control is from the return water sensor monitoring fluid temperatures returning from the heat pump units.
- PID inputs for primary control are Set Point and Return Fluid Temperature $\mathbf{T_R}$, the process variable
- Output for primary control is 0% to 100% over a 20°F change in temperature (or equivalent)
- PID integral reset value 10% of offset per minute
- 1st stage of Heat Injection is enabled at 25% PID output, 2nd stage and beyond are spread out between 25% and 0%. Each stage is disabled at 10% higher value. ie: 1st stage disabled at 35%
- 1st stage of Heat Rejection is enabled at 75% PID output, 2nd stage and beyond are spread out between 75% and 100%. Each stage is disabled at 10% lower value. ie: 1st stage disabled at 65%
- 5 Minute inter stage delays should be incorporated into the ON staging only.

Analog output control functions are set up as follows:

- Primary control is from the supply water sensor monitoring fluid temperatures supplying the heat pump units.
- PID inputs for primary control are Set Point and Supply Fluid Temperature $\mathbf{T_S}$, the process variable
- Output for primary control is 0% to 100% over a 20°F change in temperature (or equivalent)
- PID integral reset value 10% of offset per minute
- Heat Injection is enabled at 25% PID output with a 0v output increasing to 10v at 0% PID output
- Heat Rejection is enabled at 75% PID output, with a 0v DC signal increasing to 10v at 100% PID output

Advanced Features: While CGC recommends that devices such as boilers and heat rejectors that are staged on and off be directly operated from the primary PID algorithm (with return water temperature as the controlled variable) to minimize equipment cycling, ***modulating*** equipment such as valves or modulating boilers are best controlled from discharge temperature **Ts**. Systems ***with both step control and modulating control*** should be controlled via the same primary PID output control for the staged outputs with $\mathbf{T_R}$ as the variable input; but with the addition of a second PID control algorithm that is enabled as a step from the primary PID. This secondary PID will use the same setpoint as the primary PID, but the temperature input variable will be from the discharge fluid temperature sensor **Ts**. With this arrangement the discharge temperature control will only function when enabled by the primary PID control. Overshooting and cycling will be prevented. However, if staging is not required for either heat injection or heat rejection (no steps on heat input or heat rejection), the primary control sensor should be switched to the supply fluid temperature sensor **Ts** and the second PID algorithm will not be required.