12 Chillers and Central Plant

In the redesign, there are two separate plants. One is located on the roof and conditions air in the AHU. The primary requirement of this plant is to handle latent load. The central plant produces hot and chilled water for the radiant panels. This plant accounts for the majority of sensible loads. Because of the enthalpy wheel, total plant size (cooling) can be reduced by **5.9 tons**. (see Section 13.1)

12.1 AHU Chiller

The AHU Chiller's main function is to handle latent loads. By cooling outdoor air to 42F, moisture is removed and the dry air ensures a dry conditioned space. Latent load calculations can be found in Section 11.1.

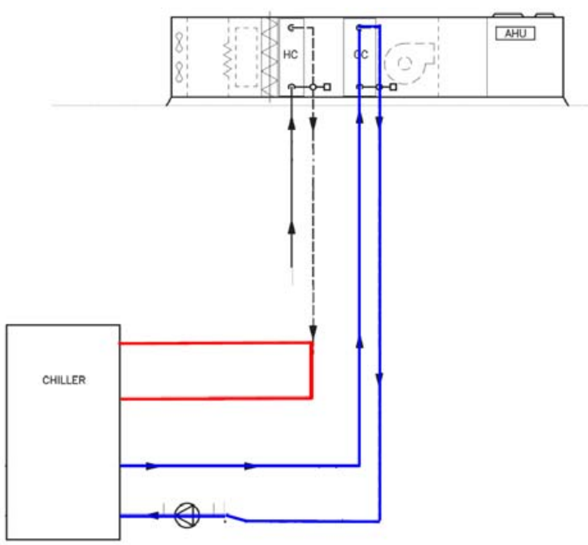

Figure 12.1.1.a. Chiller in heating mode

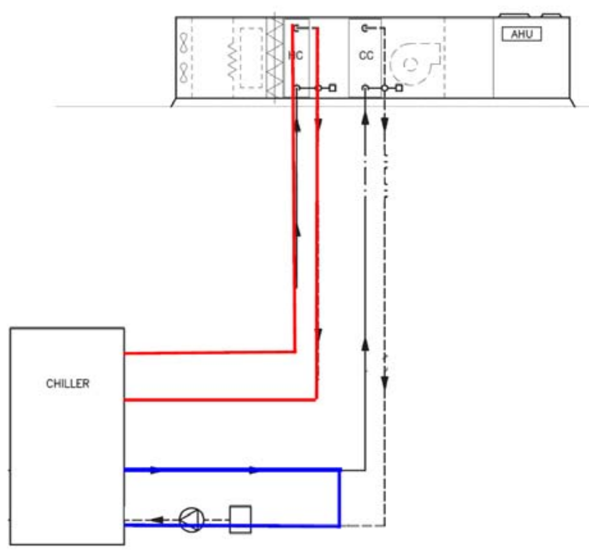

Figure 12.1.1.b. Chiller in cooling mode

As seen in the figure below, the chiller will heat or cool the space depending on outside air temperature. Heat rejection occurs into the atmosphere. To size the chiller, one can use the following equation:

$$Q=1.08*CFM*(T_{ew}-T_{supply}) \quad (12.1.1)$$

Q=1.08*5110*(77.2-42) = 194 kBTU/hr = **16.2 tons**

According to TMY data[j], the minimum temperature during occupancy hours is 20F. Assuming $COP_{heating} \approx COP_{cooling}$, the following equation shows supply air temperature at design heating condition:

$$T_{supply} = T_{ew} + Q/(1.08*CFM)$$

$$T_{supply} = (20+.8(70-20)) + 194000/(1.08*5110) = \mathbf{95F}$$

Since supply air temperature is not critical, any number above 70F is acceptable.

12.2 Central Plant

Changing to DOAS will make several key effects on the central plant. The heat recovery chiller now solely supplies water to the radiant panels. Also, operating temperatures change which affects both flow and efficiency.

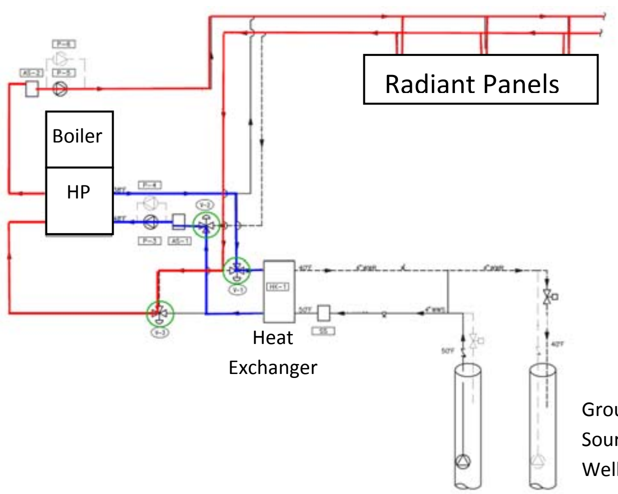

Figure 12.2.a. Central Plant During Heating

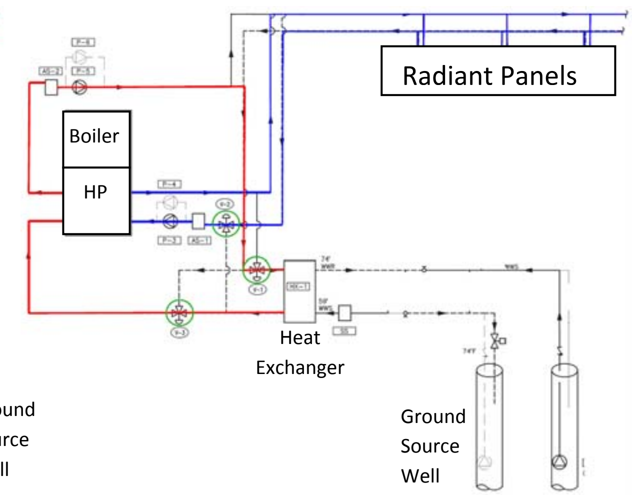

Figure12.2.b. Central Plant During Cooling

The chiller can be downsized by 16.2 tons because of the addition of the AHU chiller (in addition to reduction in energy from the Enthalpy Wheel, section 13.1)

Table 12.2.1. Chiller size

Original Size	AHU Chiller	Enthalpy Wheel	Redesign Size
123.5[1] tons	16.2 tons	5.9 tons	101.4 tons

[1]Appendix G

Because of the radiant panels, the chiller now operates at a higher temperature. This increases the efficiency of the chiller. In heating mode, the heat recovery chiller stages with the natural gas boiler to provide full heating capacity.

Using a heat pump with radiant panels poses a potential problem. Heat pumps like low condenser loop temperatures to keep efficiency high. Radiant ceiling panels work best at higher temperatures. At a high ΔT, heat transfer is primarily radiation and with a lower ΔT, heat transfer is dominated by convection. With radiant ceiling panels, one would like to keep heat transfer as primarily radiation, since convective transfer will stratify the air and keep hot air at the top of the space. To solve this, increase the ΔT of the hot water loop from 20F to 40F. By staging the heat pump and boiler, it allows the heat pump to work from 100F-120F, its optimal operating range. The boiler increases the hot water to 140F. This gives a Mean Water Temperature (MWT) of 120F. This is on the low side of radiant ceiling panel temperatures, but still acceptable (Appendix F). Increasing ΔT will also reduce GPM which reduces copper piping size. The only issue may be radiant asymmetry from the start to finish of the panel. However, since all heating is confined to less than 10' of the perimeter, this should not be a problem. The following table gives a list of operating temperatures and GPM flows for the central plant.

Table 12.2.2. Central Plant Operating Details

	Operating Temperature	ΔT	GPM
Original (Cooling)	52F-38F[1]	14F	140[1]
Redesign (Cooling)	56.5F-61.5F	5F	225
Original (Heating)	100F-120F[1]	20F	112[1]
Redesign (Heating)	100F-140F	40F	45

[1]Appendix G

Note that as ΔT varies, GPM changes inversely. Also, as GPM's go down, so do pumping costs. In the redesign, cooling GPM's go up, but heating GPM's go down. Once can assume that these values would be close to offsetting each other. Also, since pump energy is minimal compared to fan energy, the scope of this report does not include yearly pump energy differential.