# 11 Radiant panels

Radiant panels now handle the majority of sensible loads in the building. As the name suggests, the panels use radiant heat transfer to condition the building. Water flows from the central plant to the radiant panel. Heat transfer occurs from copper piping inside of the panel, into the space as seen in the figure below.

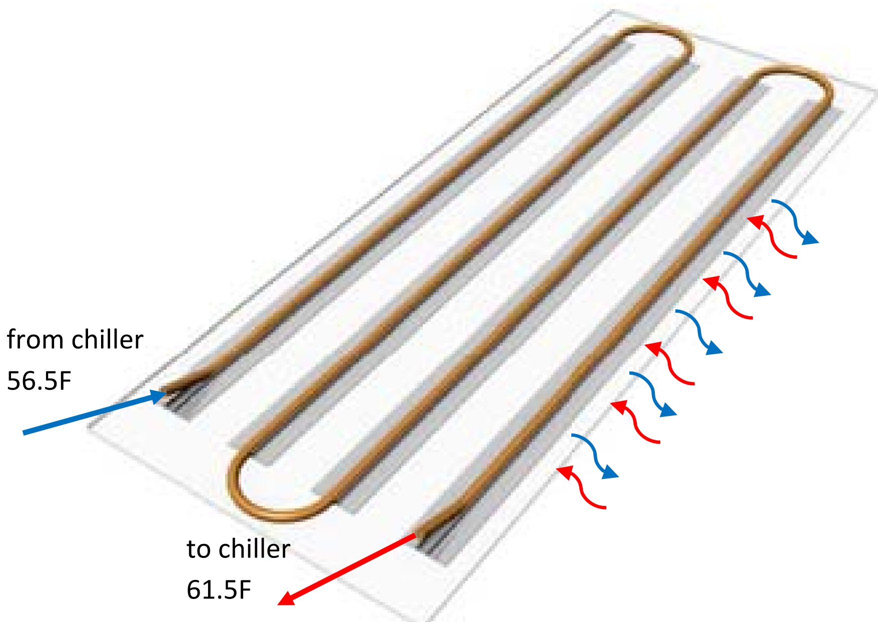


Figure 11.1. Radiant Panel shown in cooling mode[g]

## 11.1 Cooling Panel Design

*SIZING*

The following table shows calculations for a few sample spaces for sizing the radiant panels for cooling. Panel ΔT is 5F, with a 56.5F inlet temperature. Total load is estimated from equation 13.1, with CFM equal to supply air at the Fan Terminal Unit for each zone and supply air as 55F. This number is conservative, since designers estimated supply air before loads were known.

Table 11.1.1. Cooling Panel Sizing

| Description | Area | Load | Vent Air | Air Sensible Capacity | Sensible Load | Area Panel[1] | Percent Ceiling |
|---|---|---|---|---|---|---|---|
| | SF | BTU/hr | CFM | BTU/Hr | BTU/Hr | SF | |
| **Open Office[2]** | 593 | 18878 | 81.5 | 2817 | 16062 | 422 | 71.3% |
| **Open Office[2]** | 608 | 23803 | 83.6 | 2889 | 20914 | 550 | 90.5% |
| **Open Office[2]** | 400 | 13953 | 55.0 | 1901 | 12053 | 317 | 79.3% |
| **Open Office[3]** | 1878 | 19288 | 258.2 | 8923 | 10365 | 398 | 21.2% |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Conference**[3] | 400 | 10054 | 196.7 | 6798 | 3257 | 108 | 27.1% |
| **Total For Building** | 42318 | 762900 | 5110 | 199000 | 563900 | **17615** | 41.6% |

[1]Appendix E
[2]Perimeter Zone
[3]Interior Zone

With radiant ceiling panels, there is a risk of condensation forming on the coils. If the dew point of the space reaches above the temperature of the cooling coil at the inlet (coldest point), condensation will begin to form. This would eventually cause water to drip onto occupants and equipment. The room design conditions for cooling are as follows:

Figure 11.1.2. Radiant panel in an office[h]

Table 11.1.2. Room Conditions

| Dry Bulb | Relative Humidity | Humidity Ratio | Dew Point | Chilled Water |
|---|---|---|---|---|
| **74F**[1] | 50%[1] | .0089 lb/lb | **54.3F** | **56.5F**[2] |

[1]Table 6.2.1
[2]Table 12.2.2

The dew point of the space is below the coldest temperature of the radiant panel. As long as design conditions are maintained, there will be no condensation. For design conditions to be met, any latent load must be handled. Below is a sample latent load calculation from a space with the highest latent load – a 400 square foot conference room. As shown, the latent capacity of the supply air is plenty to handle peak latent load.

Latent Load = 37 BTU/hr/person*occupancy (11.1.1)

Latent Load = 37*26.7 = **988 BTU/hr**

Latent Capacity = 4838 * CFM * ($W_{room}$-$W_{supply}$) (11.1.2)

Latent Capacity = 4838*81.5*(.0089-.0058) = **2950 BTU/hr**

*CIRCUITS*

Radiant panel circuitry must also be designed. The following equation is useful for finding flow rate.

$$GPM = BTUh/(500*\Delta T) \quad (11.1.3)$$

$GPM_{total} = 563900/500/5 = 225.5$ GPM

One would like total pressure drop in the circuit to be in the vicinity of 5' of head. The following table shows calculations for panels and flow rate. Note that each panel is 2'x4'.

Table 11.1.3. Panel and Flow Rate calculations

| Description | Sensible Load | Area Panel | Panels | Flow Rate |
|---|---|---|---|---|
| | BTU/Hr | SF | | GPM |
| **Open Office** | 16062 | 422 | 53 | 6.42 |
| **Open Office** | 20914 | 550 | 69 | 8.37 |
| **Open Office** | 12053 | 317 | 40 | 4.82 |
| **Open Office** | 10365 | 398 | 50 | 4.15 |
| **Conference** | 3257 | 108 | 14 | 1.30 |
| **Total** | 563900 | 17615 | **2202** | **225.5** |

If one assumes 8 panels per circuit we get a head of 3' per circuit.

Table 11.1.4. Circuit design

| Panels/Circuit | Total Circuits | Flow Rate/Circuit | Head per panel[1] | Head per circuit |
|---|---|---|---|---|
| **8** | 275 | .820 | .376' | 3.01' |

[1]Calculation Appendix

*LAYOUT*

Radiant panels should be spread out evenly over each zone. In perimeter zones, panels will cover most of the space, and will be much sparser in interior zones (see Table 11.1.1). Wherever radiant panels cover more than 70% of a zone, full ceiling systems will be used[i]. This is primarily at perimeter zones, and will also help coordinate with heating panels (see Section 11.2)

## 11.2 Heating Panel Design

*SIZING*

There are a few key differences when sizing heating panels. In the McKinstry Oregon Headquarters, all heating load is through the building envelope, and is equal across the entire perimeter. The eQUEST model from Technical Report 2 (Wyczalkowski) gives total heating load per floor. Panel ΔT is 40F, with an intlet of 100F. This is a large number however is acceptable providing expansion tanks are adequately sized.

Table 11.2.1. Heating Panel Sizing

| Floor | Total Load | Perimeter | Load/ft | # Tubes[1] | Panel Width[1] | Area | Total Flow[2] |
|---|---|---|---|---|---|---|---|
| | BTU/hr | Ft | BTU/hr/ft | passes | ft | SF | GPM |
| 1st | 440000 | 625 | 704 | 10 | 5 | 3125 | 22 |
| 2nd | 446000 | 625 | 714 | 10 | 5 | 3125 | 22.3 |

[1]See Appendix F
[2] Equation 11.1.3.

Heating load is slightly higher on the second floor. This is due to roof exposure, which is greater than heat loss through slab on grade at the first floor level.

*CIRCUITS*

Using equation 11.1.3 we can find total flow rate for each floor. For this calculation we will assume a circuit flow of 1 GPM, and then check if head loss is appropriate.

Table 11.2.2. Heating Panel Circuit Head Calculation

| Floor | Total Load | Total Flow | Circuit GPM | #circuits | circuit length | Tube length[1] | Head/ 100ft[2] | Circuit Head |
|---|---|---|---|---|---|---|---|---|
| | BTU/hr | GPM | GPM | | ft | ft | ft $H_20$ | ft $H_2O$ |
| **1st** | 440000 | 22 | 1 | 22 | 28.41 | 284.1 | 2 | **5.61** |
| **2nd** | 446000 | 22.3 | 1 | 22.3 | 28.03 | 280.3 | 2 | **5.68** |

[1]Length = Perimeter/Circuits; 10 tubes/circuit
[2]See Appendix F

*LAYOUT*

Since all heat loads are on the perimeter, panel layout should be around the perimeter of the building, and work inside. The perimeter also needs to be cooled, so these panels would over lap. Here, a 4 pipe system will be used, so the panels can provide both heating and cooling.

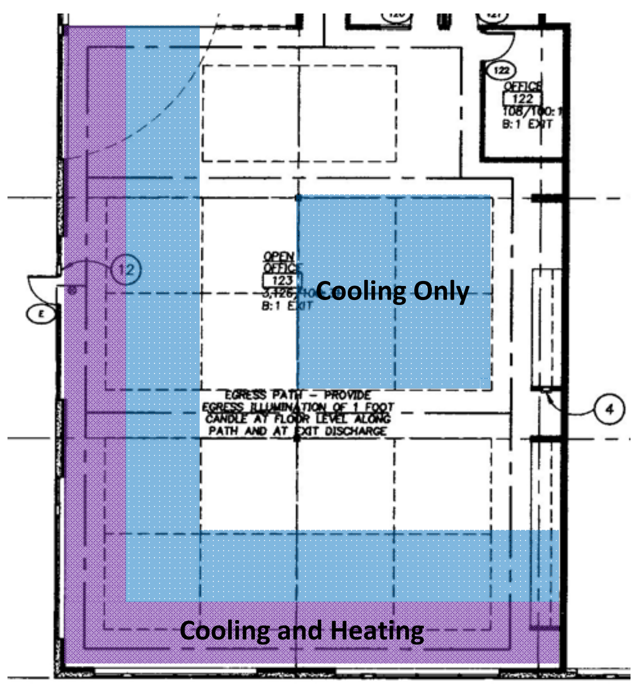


Figure 11.2.1. Radiant Ceiling Panel Layout