Underfloor Air Mechanical Systems: Project Profile, Findings and Lessons Learned

June 12, 2010

This paper is based on details and finding provided by Larson Binkley, Inc. Overland Park, KS. The lessons contained in this white paper where gathered from an owner occupied building where the Interior cubicle spaces were being over cooled resulting in frequent occupant complaints. Occupants in the perimeter offices were experiencing significant warm-up throughout the day resulting in hot offices. Corrective action was taken to fix the following findings:

1) The average return air temperature was a few degrees below the average space air temperature.

2) Air handling equipment serving the same plenum was supplying different air volumes between units for the same floorplate.

3) The size of the perimeter zone had been extended beyond the original design.

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Underfloor Air Mechanical Systems

Project Profile, Findings and Lessons Learned

Project Profile:

Type:	Owner occupied office building
Location:	Kansas City, KS
Size:	6 stories 300,000 gross sq ft
Occupied:	Over 1 year

Owner/Occupant Complaint:

Interior cubicle spaces were being over cooled resulting in frequent occupant complaints. Occupants in the perimeter offices were experiencing significant warm-up throughout the day resulting in hot offices.

Findings:

1) The average return air temperature was a few degrees below the average space air temperature.

2) Air handling equipment serving the same plenum was supplying different air volumes between units for the same floorplate.

3) The size of the perimeter zone had been extended beyond the original design.

Initial Installed System:

The perimeter system, designed to heat and cool the envelope of the building, consisted of fan coil units with electric heat and variable drive fan motors serving a perimeter plenum. Fan coils were located under the floor utilizing supply air from the plenum, providing supplemental heat to linear bar floor grilles located within 6" of perimeter walls. When in heating mode, warm air was provided through the linear grilles and in cooling mode cool plenum air.

Interior areas were supplied via manual floor diffusers. One diffuser for each workstation was the general rule. Each perimeter office contained one manual diffuser in addition to the perimeter system. Other areas such as open corridors and ancillary spaces also received manual floor diffusers.

Each floor has a common return air plenum that connects all spaces to centrally located return air shafts. Each shaft (total of two) also contains supply ducts that feed each floor in two different locations. A series of branch ducts with modulating dampers were run to within 50' of the perimeter.

Figure 1: Exterior view of building

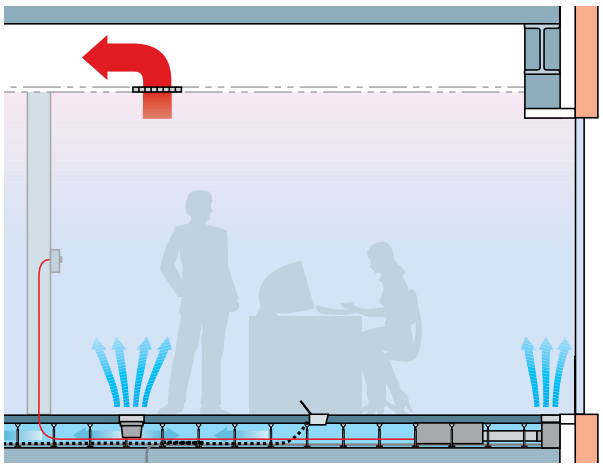

Figure 2: Fan power boxes used for heating and cooling perimeter zone

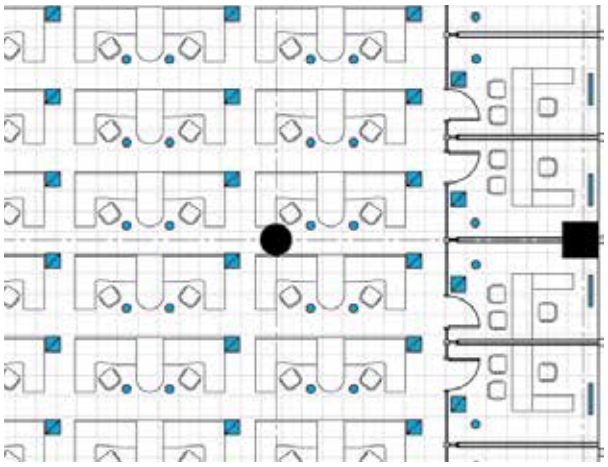

Figure 3: Diffuser(○) and return(▨) locations for interior cubicles and private offices found along the perimeter of the building.

The details and findings reported, including information for creating all figures were provided by Larson Binkley, Inc. Overland Park, KS

Finding #1:

The average return air temperature was a few degrees below the average space air temperature.

Potential Causes:

1) Category 1 Leakage: Air that leaks from the supply system without ever reaching the intended zone is defined as category 1 air leakage. Since the return and supply air share a common shaft. Air leaking from the supply shaft could be cooling the return air.

2) Category 2 Leakage: Air that leaks into the zone through openings other than the intended devices such as diffusers is defined as category 2 air leakage. This type of leakage is typically not harmful however, if it is excessive, it may over-cool the occupied zone resulting in lower room temperatures.

3) Too many supply diffusers in interior zones: Similar to the category 2 air leakage issue above, over cooling the occupied zone could result in lower return air temperatures. It may also allow for short circuiting of air closer to the return air shaft.

4) Poor placement of return air grilles: Placing a large number of return air grilles throughout the interior zone can result in lower return air temperature. Determining return grille placement largely depends on the space plan and density of the load. It is important however, to size the grilles and the number of returns such that the correct amount of air is returned from the perimeter of the building.

Corrective Action:

It was determined that too many supply diffusers had been used in the interior zones causing supply air to be short circuited through return grilles. More air was being provided to the interior than the exterior zones. It was also determined that too many return air grilles in the interior zone. The interior zones being closer to the return shaft was actually pulling more return than needed from those areas.

Remove unnecessary interior supply diffusers and relocate return grilles to exterior zones. This resulted in warmer return air temperatures and cooler air delivered at perimeter. It also pulled more heat from the perimeter allowing supply air to replace it.

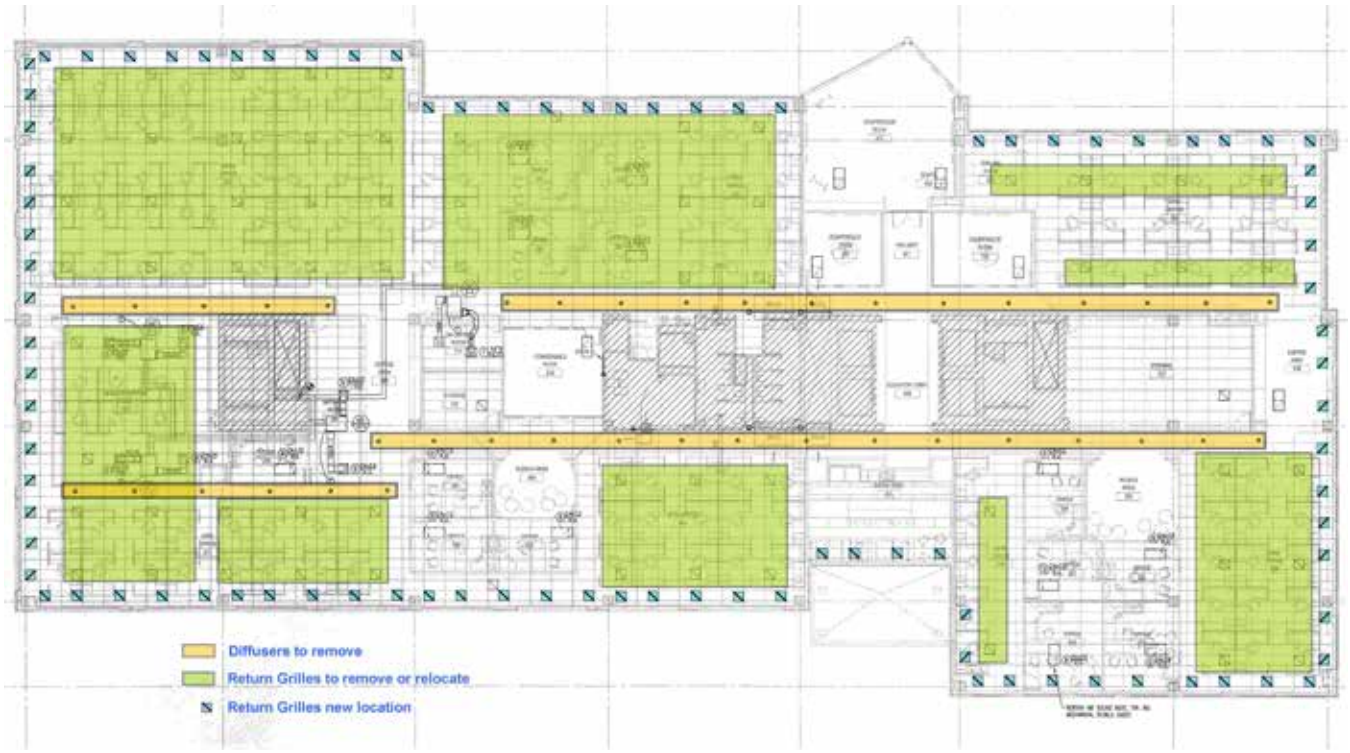

Figure 4: Shows the interior zone supply diffusers that were removed and the return diffusers that were relocated along the perimeter.

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Finding #2:

Mechanical equipment was supplying different air volumes between units for the same floorplate.

Potential Causes:

1) Equilibrium of plenum pressure occurring at different times.

2) Damper calibration or balancing required

3) Malfunction of pressure sensors, actuators, controllers, etc.

4) Poor location of pressure sensors

Corrective Action:

Each modulating damper was controlled by its own pressure sensor located under the floor. All modulating dampers were at different positions because their pressure sensor was satisfied at different times. This caused the air handlers serving each shaft to be loaded differently. Because the units were being controlled under a staggered start, the floor pressure would achieve steady state with dampers at different positions. Consequently, each air handler's fan speed would be different although shaft construction was nearly identical. This caused more air or less to be delivered through each shaft. In other words the plenum was being delivered with different capacities from each shaft.

The pressures sensors were averaged and that signal was used to control all modulating control dampers in tandem. After control changes were accomplished the same amount of air was delivered out of each shaft.

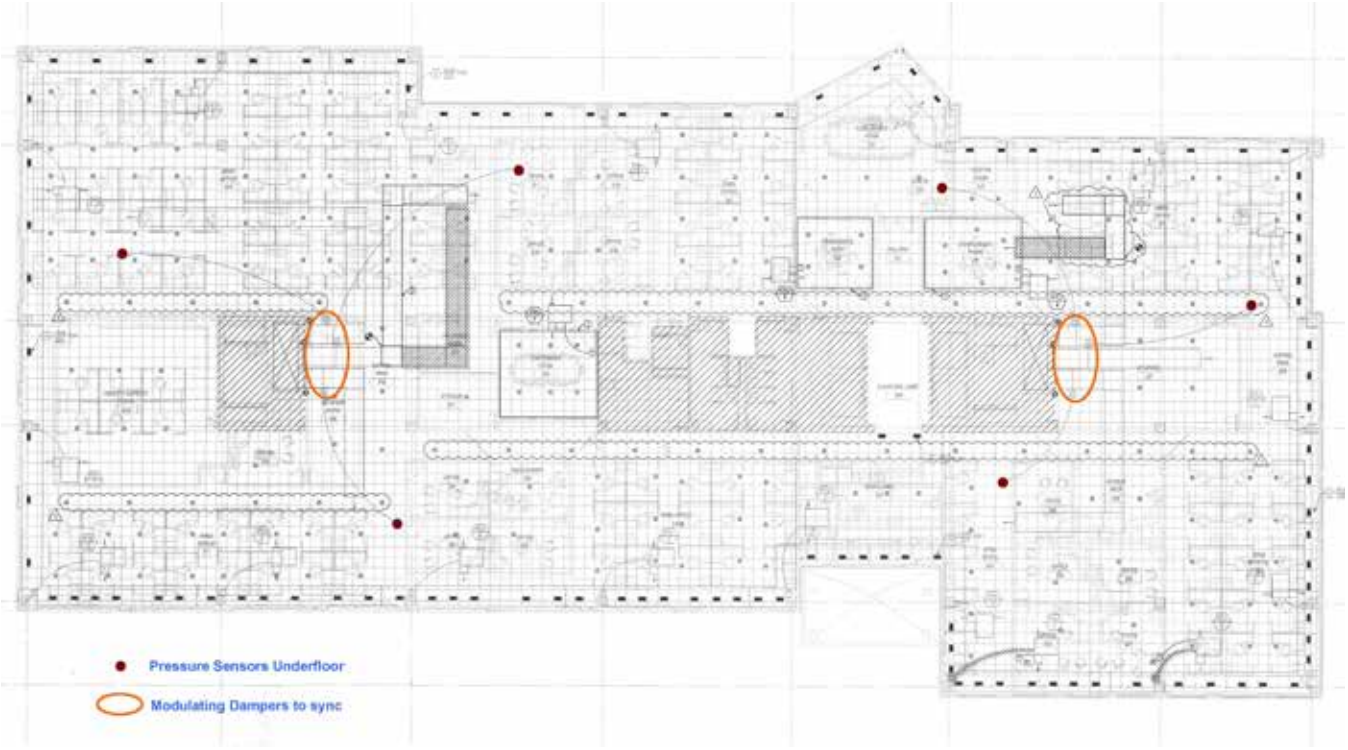

Figure 5: The location of pressure sensors to average and modulating dampers to synchronize.

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Finding #3:

The size of the perimeter zone had been extended beyond the original design.

Potential Causes:

1) Perimeter office thermostats are sometimes removed or relocated during tenant improvement.

2) Placing return air grilles to far away from the perimeter wall causing the envelope load to be pulled further interior thus increasing the size of the exterior zone.

3) Extending interior office walls through the ceiling return air plenum causing excessive restrictions in return plenum.

Corrective Action:

Thermostats and return air grilles were moved back to the perimeter so they could monitor the zone the attached fan coils were serving. Additional manual diffusers and return air grilles were added to some offices in order to handle the loads appropriately. These modifications caused the exterior load to be contained to the exterior allowing the manual diffusers to handle the interior load.

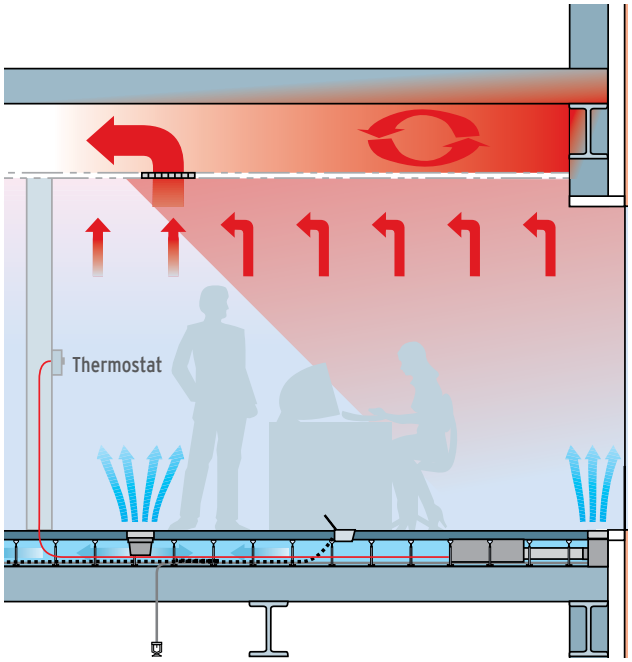

Figure 6: The location of the return grille and thermostat before corrections causing envelope load to be pulled further into the space.

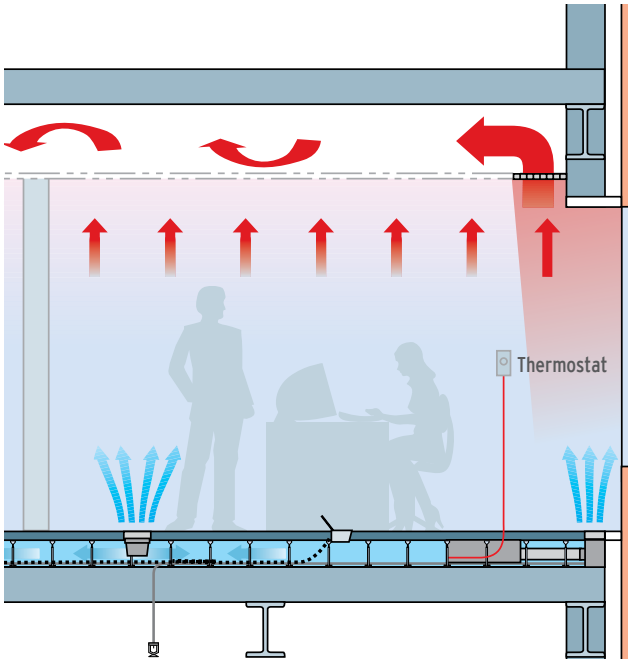

Figure 7: New location of larger return grille and thermostat that reduces the perimeter zone size to the original design.

Summary of Lessons Learned:

1) Don't locate supply air diffusers where there is no load and take floor box and panel seam leakage into account when selecting and locating diffusers.

2) Locate return air grille in the perimeter zone.

3) Control shaft dampers in tandem and average pressure sensors when serving the same plenum with multiple points of air injection.

4) Thermostats should be located in the perimeter zone that it is intended to regulate.

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