Room Temperature Control during Season Switchover with Single Duct Variable Air Volume System without Reheat

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ABSTRACT

The Langford "A" building houses the College of Architecture on TAMU campus. There are ten single-duct variable air volume (VAV) air-handling units (AHUs) without reheat serving the building. The local pneumatic thermostats modulate the dampers of VAV boxes to maintain room temperature at their setpoints. The thermostat action is switched from direct acting (DA) to reverse acting (RA) when the season changes from fall to winter and vice versa from winter to spring, based on the out side air temperature, when season changes. This results in various parts of the building ether too cold or too hot during the season change. This paper presents that the thermostat action will be switched according to cooling loads or discharge air temperature, instead of outside air temperature. For the interior zone, thermostat action does not need to be switched at all. The comfort is improved and savings is achieved by the new control scheme. Because some air-handling units (AHUs) serve both interior and exterior zones, this system never worked as intended. The system must be modified to have zone reheat and the AHUs discharge air temperature is set below dew point for humidity control.

INTRODUCTION

The Langford "A" building houses the College of Architecture on the Texas A&M University (TAMU) campus. It is four-storage with the total conditioned area of 114,440 ft^2 and faces south. There are mainly offices, classrooms, and computer labs in it.

There are ten air-handling units (AHUs) in the penthouse on the roof. The AHUs are single-duct with variable air volume boxes without reheat (SDVAV). Figure 1 gives an example of the AHUs. The return air is brought back to the AHU through the return fan. There are two dampers on the fresh air duct. One is a minimum air damper and another is a maximum air damper for the economizer. There is a couple-control for the maximum air damper and the relief air damper. When the maximum air damper is fully open as an economizer, the relief air damper is fully open also. The preheat coil is for the heating and freezing protection in winter. The cooling coil is for cooling in summer. Both supply fan and return fan possess variable frequency device (VFD). There is direct digital control (DDC) on the AHUs through energy management control system (EMCS), for instance, supply fan and return fan start/stop and their variable frequency drive (VFD) speed, chilled water and hot water control valve positions, fresh air

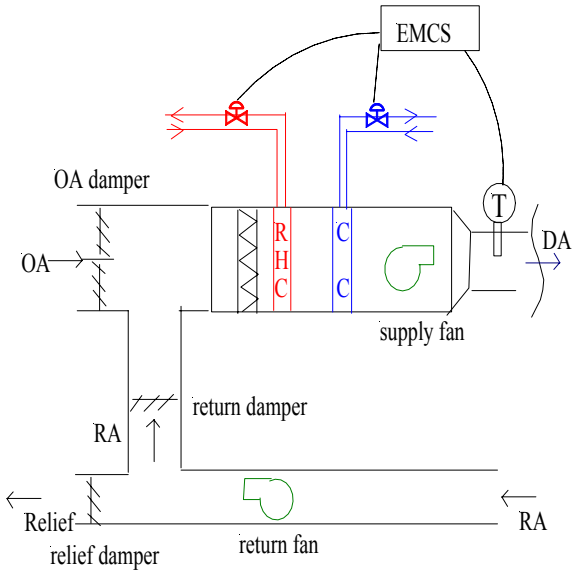

Figure 1 Typical AHU System of Ten AHUs

Table 1. AHU Performance

AHU #	system	serving area	conditioning ft^2	total CFM	fan hp	chw GPM	cooling MBTU/H	hw GPM	heating MBTU/H
1	SDVAV	SW corner raiser	7420	13,175	20	83.2	452.8	21.1	315.9
2	SDVAV	SW interior raiser	10540	18,640	30	83.3	522.6	8.3	124.2
3	SDVAV	middle S exterior raiser	8300	14,745	25	117.1	524.2	16.6	248.4
4	SDVAV	middle S interior raiser	14000	24,665	40	128.6	782.2	10.2	151.8
5	SDVAV	SE corner raiser	9600	15,865	25	136.8	575.8	19	284.4
6	SDVAV	SE interior raiser	9900	16,915	25	71.5	429.1	6.5	96.8
7	SDVAV	NW exterior raiser	12270	19,035	30	140.4	671.9	21.7	324.8
8	SDVAV	NW interior raiser	15040	23,530	40	163.4	730	9.7	144.9
9	SDVAV	NE exterior raiser	9070	22,470	40	161.7	793	27.2	407.7
10	SDVAV	NE interior raiser	18300	15,305	25	93	559.6	6.9	102.5
total			114,440	184,345	300	1,179	6,041	147	2,201

damper position, return air damper position, and relief air damper position. The VAV dampers of terminal boxes are control by the pneumatic T-stats.

Table 1 gives the AHU performance such as airflow rate, fan horsepower, chilled water and hot water flow rates for cooling and heating coils. The conditioning area and location for each AHU is also including in table 1.

There is a chilled water pump and a hot water pump in the crawlspace underneath of the building. These two pumps have VFD and DDC remote control.

THE DESIGN ISSUE OF AHUs

The AHUs with even numbers serve the interior zone of the building. The AHUs with odd numbers serve exterior zone of the building. For example, AHU#2 serves the southwest interior zone raiser of the building and AHU#1 is for the southwest corner raiser of the building. Figure 3 illustrates the areas of the ten AHUs serve.

Each AHU has a preheat coil and a cooling coil with VAV terminal boxes, but without terminal reheat. That is a problem. In the area of College Station, Texas, it is humid in spring and fall. Without reheat coil on AHUs or in the terminal boxes, it cannot dehumidify and causes the humidity problem in the building in spring and fall. When the HVAC system was designed in 1974, it might be assumed that it didn't need dehumidification in the area of College Station, Texas. But it is not a case. In fact, most of the rainfall happens in spring and fall. For example, the October floods of 1984 ended the dry period and drought that affected South Central Texas in 1984. The next 3 years of 1985, 1986 and 1987 had above normal rainfall, however most of the 1987 rain fell in the first 7 months. To control building humidity, the reheat coil is needed for the building,

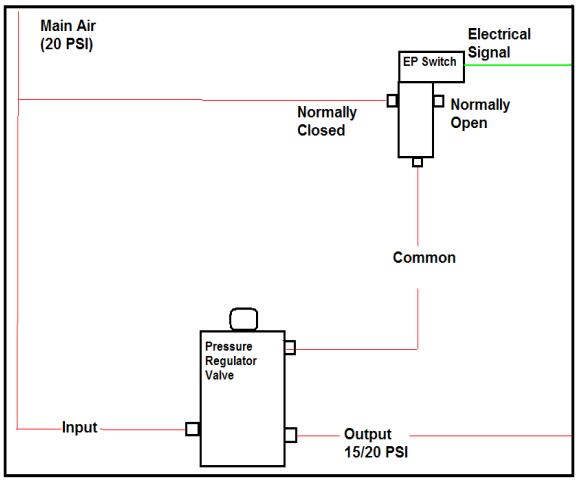

Figure 2. Compressed Air Pressure Regulator Diagram

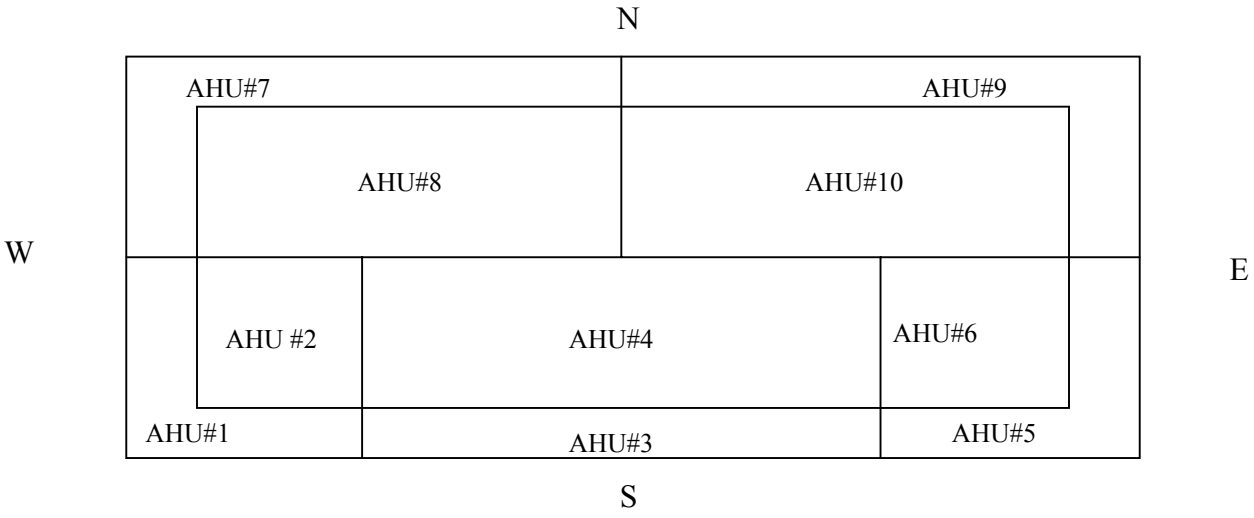

Figure 3. Typical Floor Plan of the 1st through the 4th Floors where the AHUs Serve

which is located in the humid area like Texas.

ROOM TEMPERATURE CONTROL AND ISSUES

The terminal boxes have the VAV control dampers only and are controlled by room T-stat. The cooling and heating capacities of each AHU are high enough to handle cooling load in summer and heating load in winter. The VAV damper in each terminal box is normally open and is controlled by a local pneumatic T-stat to maintain room temperature at its setpoint of 74 F°. To do so, the dual dial cooling-heating T-stats are installed to accomplish mode switchover between reverse action (RA) for summer mode and direct action (DA) for winter mode, with a change in supply compressed air pressure from 20 psi for winter mode to 15 psi for summer mode. There is a pressure-regulation valve (PRV) on each AHU to regulate the supply air pressure for the T-stats shown as figure 2. When the electronic-to-pneumatic (EP) switch is energized in summer mode or de-energized in winter mode, the output of the PRV is 20psi or 15 psi, respectively.

The building was historically cold during season changeover. The reason is the season mode was changed according to outside air temperature and ignored the discharge air temperature in the old season switchover schedule as shown in table 2. For the exterior zone AHUs, the season mode was changed from summer mode to winter mode when outside air temperature was 64 F°. For the interior zone AHUs, the season mode was switched from the summer mode to winter mode at 60 F° of outside air temperature.

Figure 4 shows the discharge air temperature changes through outside air temperature. According to old season switch over schedule, when outside air temperature is lower than 64 F°, the exterior zone T-stat action is changed from RA to DA for the VAV normally open damper control and the discharge air temperature is lower than 68.8 F°. When the room temperature is lower than its setpoint of 74 F°, the pneumatic signal pressure from DA T-stat will

Table 2: Season Switchover Schedule

AHU No., zone	Season	old schedule			new schedule	
		OAT (F°)	T-stat acting	Tdis (F°)	Tdis (F°)	T-stat acting
1,3,5,7,9, exterior zone	Winter	<64	DA	68.8	>74	DA
	Summer	>66	RA	66.3	<72	RA
2,4,6,8,10, interior zone	Winter	<60	DA	62.5	Don't switched	RA
	Summer	>62	RA	61.5	Don't switched	RA

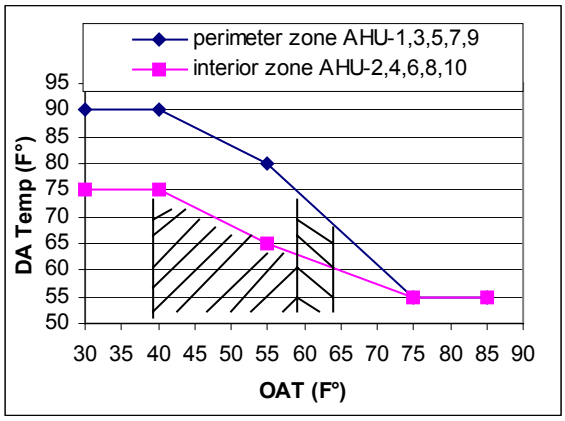

Figure 4. The Discharge Air Temperature vs. Outside Air Temperature

decease to call the damper open more. It results in more cold air comes to the room and makes the room quite cold. Until outside air temperature is 58 F° corresponding to discharge air temperature of 74 F°, DA T-stat does not work. In old season switchover schedule, when outside air temperature is between 58 F° and 64 F° for exterior zone AHUs and between 40 F° and 60 F° for interior zone AHUs, the DA T-stat makes trouble, because the discharge air temperature is lower than room temperature setpoint of 74 F° during that period. In other word, the more and more cold air comes to the room when it needs heating. Figure 5 records the average room temperature during the reason mode switch. For example, the discharge air temp is 67 F° (perimeter zone), when outside air temperature is 63.5 F°. The season mode is "winter" and the thermostat is in DA. When room temperature is lower than its setpoint of 74 F°, the damper will be called open more and more until full open. The room temperature will go down to 67 F°. This results in uncomfortable conditions and cooling energy wasted.

THE NEEW SEASON SWITCH SCHEDULE

The key to solving this problem is to reset the season switchover schedule according to the discharge air temperature instead of outside air temperature. As shown in table 2, for the exterior zone AHUs, the season mode switches over from summer mode to winter mode when discharge air temperature is 74 F°. That means the T-stat will maintain RA when discharge air temperature is below 74 F°. When the discharge air temperature is above 74 F°, the T-stat is in DA and comes back to RD when discharge air temperature drops below 72 F°. The interior zone AHUs does not need season

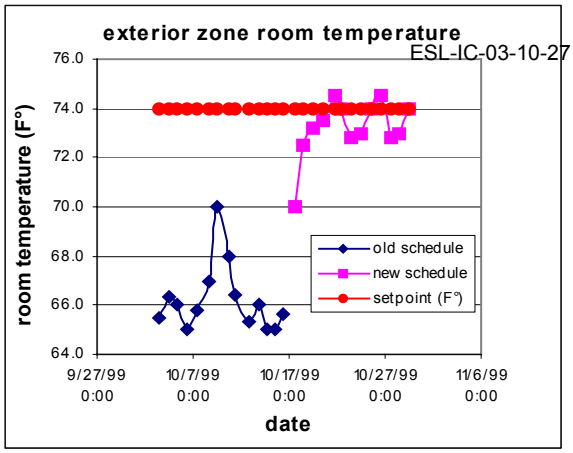

Figure 5. Room Temperature during Season Switch before and after the New Schedule

switch and is maintained in summer mode, because the discharge air temperature is lower than the room temperature setpoint all the year around.

The new season switch schedule has been in use for three years and works well. Figure 5 shows the room temperature during season switch before and after the new schedule. When the room temperature setpoint was 74 F°, the room temperature was around 66 F° with the old season switch schedule and about 74 F° with the new schedule. The new season switch schedule not only improves the room comfort during season change, but also saves energy.

Because there is no reheat in the existing AHU system, the room humidity cannot be controlled during the season change.

CONCLUSION

The AHU system without reheat can be designed for the buildings, which are located in the dry area year around, but not in the humid area like Texas. In Texas the AHU always needs reheat coils or terminal reheat.

For the season mode change, it is key to watch the discharge air temperature instead of outside air temperature. The new season switch schedule works well for room temperature control and energy savings with single duct VAV systems without reheat. Reheat coils are recommended for the VAV boxes or AHUs for room humidity control.

ACKNOWLEDGMENT

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