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ANALYSIS OF HVAC SYSTEM WITH VAV ARRANGEMENT

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Abstract - Variable Air Volume (VAV) is a type of heating, ventilating, and air-conditioning (HVAC) system. The VAV Zone Controller has a built-in actuator and maintains zone temperature by operating the terminal fan and regulating the flow of conditioned air into the space In HVAC systems, some spaces require different airflow of supply air due to the changes in thermal loads. The VAV system consists of a central air handling unit which provides supply air to the VAV terminal control box that located in each zone to adjust the supply air volume.

Keywords - VAV, plenum, Terminal Reheat, Single duct, Dual duct, Primary air, Plenum air

1.INTRODUCTION

The variable-air volume (VAV) product has been an industry leader in performance and quality for many years. The system includes single-duct VAV units, dual-duct VAV units, fan-powered VAV units (series, parallel, and low-height series and parallel), direct digital Controls, pneumatic controls, analog electronic controls, direct digital control retrofit kits and diffusers. This application section will focus on VAV units only.

2. TYPES OF VAV SYSTEMS

2.1 SINGLE DUCT VAV SYSTEMS

Single-duct systems consist of one supply fan and a single supply duct, which is attached to each zone. Depending upon cooling needs the supply fan delivers cooled air to the VAV zones in variable volumes. The supply fan is usually designed to modulate airflow delivered to the VAV zones.

Many VAV zones require heating as well as cooling. The supply air-handling unit provides either no heat (cooling only), morning warm-up heat or occupied (changeover) heat. In addition, heat may be provided at any individual VAV zone (within the zone or within the VAV terminal) by reheating cool air provided by the central air handling system.

In some systems, the central air handler provides only cooling and ventilation during zone occupied periods. The supply air is maintained at a constant temperature and the supply airflow is modulated to match the VAV airflow rate with the zone cooling requirements.

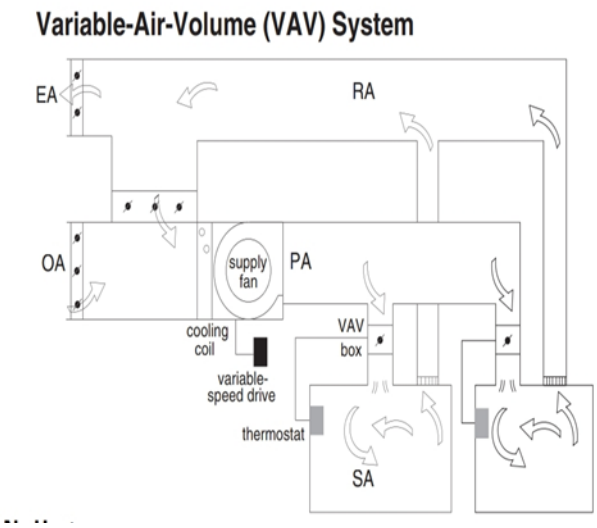

FIG-1: Single duct VAV system

2.2 DUAL DUCT VAV SYSTEMS

Dual-duct systems have either one or two supply fans or two duct systems. One duct system carries heated air and the other duct system carries cooled air. Heated air and cooled air are modulated and/or mixed at each zone in the proper proportions to control zone temperature. Terminal reheat is not required in a dual duct system.

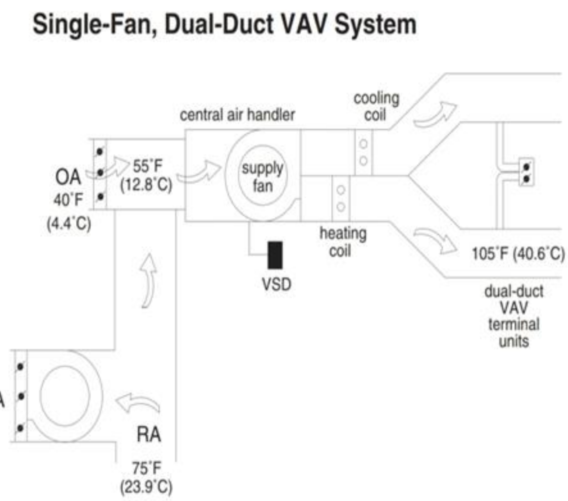

FIG-2: Dual duct VAV system

3. COMPARISION OF SERIES AND PARALLEL MODELS

Once it has been determined that a fan-powered system is to be specified, the designer must decide between parallel and series configurations. Each model carries its own characteristics of delivered airflow, energy consumption, and acoustics. For the end user, the designer might consider three goals: a comfortable and productive tenant environment, acceptable installed cost, and low operating costs. Parallel and series fan-power determinable units offer specific advantage for particular applications. The following table compares the key similarities and differences between the models that the designer should consider in performing an engineering analysis.

FUNCTION	PARALLEL	SERIES
Fan Operation	Intermittent operation during occupied and unoccupied modes.	Continuous operation during the occupied modes. Intermittent operation during unoccupied mode.
Operating Sequence	Variable-volume, constant-temperature device during cooling. Constant-volume variable-temperature during heating.	Constant-volume, variable-temperature device at all times. Delivers design airflow regardless of the load.
Fan Energization	Based on zone temperature deviation from set point. No interlock with central system fan required	Interlocked with central system fan to deliver required air to the zone in both heating and cooling modes
Heating loads	Under heating loads, the fan operates intermittently.	Less noticeable than intermittent fan operation
Terminal Fan Operating and Size	Fan runs during heating load. Size for design heating load. Typically this is 40 to 60% of design primary cooling airflow	Fan runs continually. Fan sizing should meet the greater of design cooling or heating airflow to the zone.
Air valve Sizing	Design cooling airflow.	Design cooling airflow.
Minimum Inlet Static Pressure Required for Central Fan Sizing	Sufficient to overcome unit, heating coil, downstream duct and diffuser pressure losses	Sufficient to overcome air valve pressure loss only.
Acoustics	When operating under cooling loads the terminal fan does not run, offering superior acoustic performance similar to single-duct VAV. Impact can be minimized by use of a ECM.	Produces slightly higher background sound pressure levels in the occupied space. This sound level remains constant and is less noticeable than intermittent fan operation with PSC motors.

TAB-1: Comparison of parallel and series models

3. 4.DESIGN CONSIDERATIONS

LOW TEMPERATURE AIR DISTRIBUTION DESIGN CONSIDERATIONS WITH PARRALLEL FAN POWERED TERMINAL UNITS

The parallel fan-powered unit needs to be set up to run continuously rather than intermittently. Since it is in parallel, the airflow required by the fan is less than a comparable series unit. This results in energy savings. Running the parallel fan continuously will take some minor control changes. It will,
However, create a better acoustical installation.
The parallel fan should be large enough to temper the design cooling airflow at 45–50°F to 50–55°F (7.2–10°Cto 10–12.8°C). For instance, if the design cooling airflow is 1000 cfm at55°F (472 L/s at 12.8°C), you will need781 cfm of 48°F (368 L/s of 8.9°C)supply air and 219 cfm of 80°F (103 L/s of 26.7°C) plenum air. The parallel fan can be sized for the 219 cfm (103 L/s) rather than the total room airflow. The fan airflow plus the minimum primary airflow must be checked

with the minimum airflow of the diffusers to insure that dumping doesn't occur.

If that is a concern, the minimum could be adjusted up or the fan airflow could be adjusted up. As the valve closes, the downstream static pressure will decrease because the pressure is related to the airflow. The fan will supply more air at the valve minimum condition than at design due to the decreased static pressure. This should be a consideration when calculating how much airflow would occur at the minimum valve plus fan airflow condition. The new fan airflow would be found by looking at a fan curve at the new SP point. The new SP can be calculated:

$$\left(\frac{\text{Fan Airflow} + \text{Valve Minimum}}{\text{Fan Airflow} + \text{Valve Design}}\right) \times SP_1 = SP_2$$

The following table can be used to determine what percentage of the total airflow should come from the fan to temper the supply air, assuming 80°F (26.7°C) plenum air.

Percentage of Airflow from Fan

Supply Air Temp. (deg. F (C))	Primary Air Temperature (deg. F (C))					
	45 (7.2)	46 (7.8)	47 (8.3)	48 (8.8)	49 (9.4)	50 (10)
50 (0)	14%	12%	9%	6%	3%	0%
51 (10.6)	17%	15%	12%	9%	6%	3%
52 (11.1)	20%	18%	15%	13%	10%	7%
53 (11.7)	23%	21%	18%	16%	13%	10%
54 (12.2)	26%	24%	21%	19%	16%	13%
55 (12.8)	29%	26%	24%	22%	19%	17%

TAB-2: Percentage of the total airflow

The following equation can be used to calculate the percentage:
Supply Temperature =
(%*primary temperature) + (1-%)*plenum temperature

4.2 LOW TEMPERATURE AIR DISTRIBUTION DESIGN CONSIDERATIONS WITH SERIES FAN POWERED TERMINAL UNITS

The system designer will have some concerns related to condensation on diffusers and other low-pressure ductwork accessories. For instance, if the occupied space must receive 1000cfm of 55°F (472 L/s at 12.8°C) air to satisfy to design cooling load, 715 cfm must be 45°F (337 L/s must be at 7.2°C)supply air and 285 cfm must be 80°F(135 L/s must be 26.7°C) plenum air. Therefore, the series fan-power determinable must be sized to have the air valve deliver 715 cfm (337 L/s) of supply air at design conditions, but the fan must be sized to deliver 1000 cfm(472 L/s).

The VAV terminal unit includes a fan that operates continuously. The series fan should be large enough to insure that the mixture of cold supply air and warm plenum air is 50–55°F (10–12.8°C) at design cooling flow conditions. In these types of systems, it is a good design practice to develop the system based upon 55°F (12.8°C) air being provided to the space from the fan-powered terminal unit. If a lower temperature air is used downstream of the VAV terminal unit,

2. SYSTEM OPERATION

A low-temperature air system could be done with chilled water or direct expansion equipment. A chilled water system includes a chiller plant, VAV air handlers, and series or parallel fan powered VAV terminal units. The VAV air handlers use cold water, typically around 40°F (4.4°C), from the chiller plant, to cool the supply air to 45–50°F (7.2–10°C). The volume of supply air is determined by the airflow needs of the VAV terminal units. A direct-expansion system would include a VAV air handler or rooftop with series or parallel fan-powered VAV terminal units. The supply air would be cooled to 48–52°F (8.9–11.1°C).

The VAV terminal units include a parallel or series fan with the central air handler or rooftop fan. The terminal unit fan operates continuously, mixing45-50°F (7.2–10°C) supply air with warm plenum air, to provide 50–55°F(10–12.8°C) cooling air to the occupied space at design conditions. As the cooling load in the space decreases, the VAV terminal air valve closes to reduce the flow of cold supply air and increase the flow of warm plenum air in the case of series terminal units. The temperature of air supplied to the space rises, but the volume flow rate to the space is constant for the series units.

6. CONCLUSION

- Providing VAV arrangement to an HVAC Systems, the Cop of the plant is greatly improved. The power per TR is reduced to a considerable level and also energy efficient.

- VAV systems with terminal units are that they are able to meet the comfort requirements of different zones in a building without heating and cooling at the same time.

- More precise temperature control, reduced compressor wear and lower energy consumption.

- Increased dehumidification. Because VAV air flow is reduced under part-load conditions, air is exposed to cooling coils for a longer time. More moisture condenses on the coils, dehumidifying the air. Thus, although a constant-volume and a single-zone VAV unit maintain the same room temperature, the VAV unit provides more passive dehumidification and more comfortable space conditions.

7. REFERENCES

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