5 Questions to Ask When Deciding: To VVT or to VAV?

When it comes to zone control for air systems, there are two main properties that affect heating and cooling: airflow and temperature.

This is governed by the equation:

(Heat gain or loss) = 1.08 x (Airflow) x (Temperature Difference) where the temperature difference is the difference between the supply and return air temperatures.

Both Variable Air Volume (VAV) and Variable Volume and Temperature (VVT) systems vary airflow to control zone conditions. As the name suggests, the VVT system also varies temperature.

But which one is right for your application?

First, let's look at the common traits between the two systems.

Both VAV and VVT systems have terminal boxes controlled by zone thermostats. They are both connected to air systems that, more often than not, provide ventilation as well. (In some cases, a dedicated outdoor air system, or DOAS, might provide ventilation separately from the main air supply). For typical systems providing ventilation, the terminal box must have a minimum open position, usually around 20%.

The objective of both systems is to have individual zone control on a central HVAC system.

What is a VVT System?

Unitary systems such as packaged rooftop units form the core of the VVT system. From here, ductwork branches out to serve the spaces being heated and cooled. Every zone has its own terminal box which modulates to allow varying flows to the zone, as required by the zone thermostat.

Two characteristics unique to VVT systems:

1. Controls: Variable volume and temperature systems use a "voting" function to switch between heating and cooling depending on how many zones are calling for heating vs. how many are calling for cooling. During the dead of winter or height of summer, when all zones either need heating or cooling, there is less risk of severe discomfort. When both modes are required in different zones, the

result is inevitable dissatisfaction while the unit is in the “wrong mode” and the damper to that zone is closed.

2. Fan flow: The unit fans run at 100% speed at all times. When the boxes start closing, the upstream pressure increases. A pressure sensor in the main supply duct opens a damper located in the bypass duct directly connecting the supply and return airflows. VVT systems are thus set up to maintain a constant pressure in the system.

Once all the zones are satisfied and there is no call for the other mode (heating or cooling), the compressor or burner can shut off until needed.

What is a VAV System?

VAV systems are typically used with central plant systems. While they, too, have a main supply point that branches to the various zones, there is no “heating mode” or “cooling mode” as with the VVT system. The supply air temperature is controlled using the boiler and chiller to heat or cool as the case may be but the supply temperature doesn't change. During shoulder seasons, the outside air might be at the right temperature to supply to the zones, allowing the boiler and chiller to shut down, saving energy.

Since VAV systems have a constant supply temperature, reheat on each box is commonly used for tighter zone control.

VAV characteristics are:

1. Controls: There is no averaging and switching between modes in a VAV system. Typical designs use return air temperature to modulate heating and cooling but supply temperature is always the same.

2. Fan Speed: Supply fans have variable frequency drives which reduce fan speed when terminals close and require less air. This also maintains a constant pressure in the system, but does so by varying airflow at the supply fan itself.

VVT or VAV? When deciding between them, you have to answer these 5 questions:

1. **How much can you afford?** VVT systems have a lower capital cost. Rooftop units are cheaper than central plants with boilers, chillers and associated piping and controls. VFD fan motors cost more than constant flow fans in a packaged unit. But remember: you get what you pay for. As previously mentioned, the switch between heating and cooling modes results in poorer building control overall.

2. **How much space do you have available and where?** VVT systems require a bypass duct between the supply and return ducts at the unit. For retrofits to existing equipment, this means having headroom available for the bypass duct. Both VAV and VVT systems require ceiling space for terminal boxes and straight lengths of ductwork. For low-rise buildings with flat roofs, rooftop units are more attractive than carving out a mechanical room for a central plant, leaning the design towards a VVT system.

3. **How much temperature variance can you tolerate?** VVT systems "timeshare" between heating and cooling when both are required from the same unit. There this is particularly important during the shoulder seasons, or for buildings that need interior cooling during heating season. VAV systems, with their constant temperature supply, can satisfy its zone regardless of what neighbouring zones need by simply varying the airflow.

4. **Is there another heat source in winter?** Since VAV systems use a constant temperature, you need to decide whether to put reheat on each box. If the building has perimeter heating (hydronic or electric), you can simplify the design and leave out reheat. This option comes with its own challenges like decreased humidity control in summer (you can't cool the air to lower temps to remove moisture and then reheat to required supply temperature, unless you do it at the air handler level) and the possibility of an over-cooled (or under-heated) interior. VVT systems vary temperature and don't require reheat. It's important to note that supplementary perimeter heating is best practice for both systems in commercial design.

5. **Which one has lower energy consumption?** VAV systems use variable frequency drives (VFDs) to slow the supply fan speed when the dampers in the boxes close. VVT systems maintain a bypass between the supply and return ducts to the unit, meaning that the fan runs full tilt regardless of whether the VVT boxes are fully opened or averaging 20% open. From this perspective, VAV systems are the clear winner.

Cost plays a major role in engineering decisions, and a VVT system's low initial cost makes it the more attractive of the two options for smaller budgets. For retrofits on buildings with existing rooftop units, a VVT system is the clear choice.

When considering zone control, however, VAV systems demonstrate superior performance and result in far fewer complaints from occupants. Constant supply air eliminates situations where terminal boxes are closed waiting for the central system to switch to the right mode. The owner receives the added benefit of energy savings without sacrificing thermal comfort and performance.

Sample Article

Much thought must go into designing the right system for your particular application and it all starts with choosing the ideal one. These five questions will guide your initial decision so you can design the best system for your client's building.

RGD Industries Inc. is an air systems manufacturer specialising in accessories for variable airflow design. Our terminal boxes are equipped with a dual damper linkage that widens airflow range while maintaining tight temperature control for both VAV and VVT systems. We provide you with technical support from the initial design concept to final installation. Visit us at www.rgdair.com or call us at 1-800-RGD-AIRE to discuss your next variable air system project.