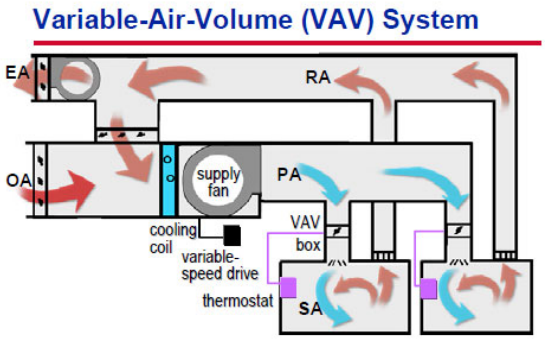
VAV Design and Controls Engineering

Yes this is another article from the old pro. I had to get up from my rocking chair to write this so you better read it.

The first and most important knowledge required for a good controls engineer is not programming skills or how the actual controls function. The most important knowledge is system knowledge. You must know the HVAC system or the industrial process as well as possible. That's right you have to know what you're controlling and how to control it!

So you think you know how to design VAV systems and their controls? This article is going to offend a lot of Engineers. Too bad!



The VAV system

Quote from PG&E and UC Berkeley's Center for the Built Environment
"A zero net energy (ZNE) buildings generate as much energy as it consumes annually."
Energy = heat

As I go on to discuss the original theory of the VAV system please keep the above quote in mind. (The lighting, plug load and people can completely heat the interior of the facility.)

They said Kid; you have to know systems to be a good Controls Engineer.

In the early 1920s identical twin boys were born in a one room home in Iowa. Ma and Pa Ginn welcomed Lee Roy and Leroyce into the world. Born on April fools day the parents jokingly referred to their sons as Sloe and Dry Ginn. As the boys grew up the names stuck and no one knew which one was which or their true names. Why do I mention these two guys because they were the smartest controls people in the nation in the late 60s and 70s? They were inventors with several patents and they changed the

way controls were distributed. The twin Brothers had major impacts on the VAV design and controls.

If mechanical contractor or building engineer wanted pneumatic controls; the controls manufactures basically said sure a technician will come out and install. If you wanted just the controls, not the technician and you pressured them they would agree but it would take months to get your controls. The Ginn Brothers started training, designing and distributing directly to mechanical contractors and building engineers.

They don't make them like they used too.

The VAV System became popular in the Los Angeles and San Francisco areas. Sloe and Dry Ginn designed the first VAV system controls in the early 70s. We were then successful in teaching the innovative Design Build Mechanical Contractors on installing their own controls, customized to their VAV concept.

The design build contractors were motivated by greed and secrecy to install their own pneumatic controls. Keeping their VAV designs in-house gave them the competitive edge to wealth in the HVAC industry. The drawings were always locked in a job box or taken home at night. Sharing this information to their competitors was not in the game plan. They didn't believe that the big control manufacturers could keep the secret of their lucrative VAV designs.

The secretive design of the original VAV system is why the VAV system of today is so screwed up. I know you've installed thousands of these systems and no one complains etc. Well you just don't know any better. If you interview the occupants you would get an ear full of complaints.

The Cat's out of the bag.

The original controls smarts and parts distributor (I won't mention their name) was mainly responsible for distributing the VAV system designs to the plan and spec mechanicals and then eventually to the consulting engineers.

The plan and spec mechanical contractors instantly became design and build contractor’s low bidding on the lucrative building boom of the 80s. With no guidance or experience the VAV system design evolved into the cheap low bid piece of crap system. *Do you want to know how I really feel?*

After thousands of screwed up HVAC systems the building owners turned to the consulting engineers for improved installations. The consulting engineers were talented experts in designing constant volume reheat and double duct systems. They had no training or experience with the **secretive VAV concept and design**.

The Design Theory VAV Systems

The engineering theory of the VAV system is based on supplying heat/cool only to the skin of the perimeter of the facility. With lighting providing the majority of heat to the interior, so in theory cooling only is required for the core of the facility.

The first VAV systems consisted of perimeter systems and usually slot diffusers providing heating and cooling with separate systems for different sun exposures of the facility. All the windows were conditioned with low velocity constant volume HVAC. There were multiple ways of conditioning the perimeter from baseboard heaters but they all protected against the sun and cold from outside. Very little heating was required and only the foot of space to the perimeter was conditioned.

The lights, people and plug loads provided the heat source for the interior of the facility.

The interior was strictly cooling only. Three AC systems provided cooling. Example; East, West and Core AC Systems.

Morning warm-up consisted of the interior VAV boxes opening 100% until the return air temperature reached setpoint. In colder areas the interior systems were HVAC.

At time of occupancy all of the interior zones were cooling only and the VAV box damper modulated from 0% to 100% open.

Heat/cool only to the skin of the perimeter of the facility

2,3 or sometime 4 Perimeter HVAC Systems

Original variable volume system design

The birth of the stupid minimum position air flow

Indoor air quality was and still is a serious problem in the industry.

It was my opinion that the perimeter systems be 100% outside air during occupancy and full return air in the unoccupied warm-up period. This would require larger capacity heating and cooling, central returns and expensive ductwork. In the summertime night purge with 100% outside air would exhaust the toxic chemicals thoroughly prior to occupancy.

In 1980 my boss came to me and said the consulting engineer is requiring that we allow a minimum flow of air into the condition space without any temperature control. I said it won't work. He explained to me that the minimum flow of air was slightly less than the heat generated from the lights within the controlled zone. So we tried it, unfortunately people would turn off their lights and in conference rooms you could hang meat from the cold temperatures. So the service technicians and building engineers started turning the minimum position completely off. It's still being turned off today by the same people trying to maintain the system temperatures and sometimes even when it's a 50% reheat design.

To make minimum position work the consulting engineers introduced reheat (*cool the air down, then heat it back up)* back into the VAV design. You can't beat a reheat system for good temperature control, but what a major setback for energy savings. This design requires that the boiler operates all through the winter and summer in a large percentage of facilities.

The perimeter of your building!

The death of the VAV system slot diffuser

Have you ever noticed in your home, next to each window there is an (air outlet) diffuser blowing heating and cooling on your windows?
The same basic principle applies to your commercial building.

In large commercial office buildings, 90% of these facilities have a separate HVAC system that conditions the perimeter windows of the building.

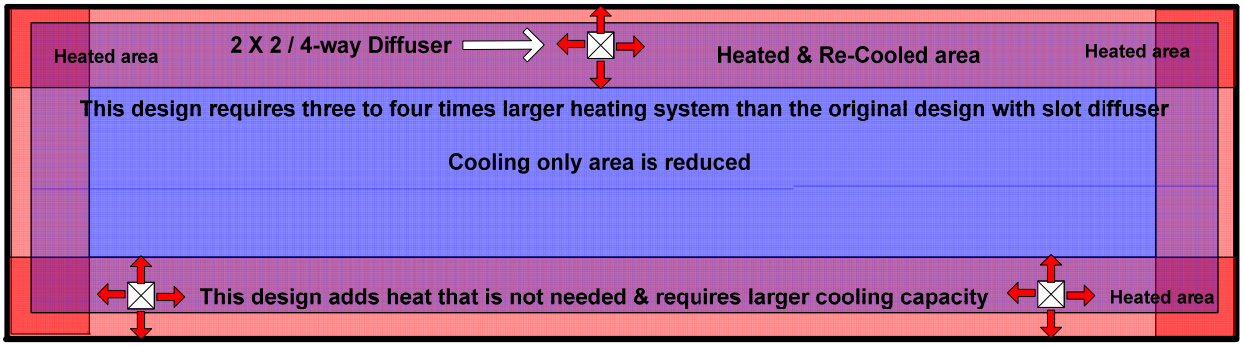
No diffusers by the windows, is a *common problem* with medium to small commercial facilities. Windows allow the heat from the sun and cold to penetrate into the condition space.

Quality HVAC systems start with conditioning the perimeter. The interior areas have different heat load requirements than your window perimeter areas.

Most (two-story 40,000 square feet and larger) commercial office buildings employ a VAV (variable air volume) type HVAC system. VAV systems that do not condition the windows with slot diffusers are not only having problems with the temperature, but are also wasting a great deal of energy.

Four way directional diffusers put ¼ of its heated air toward the window from a six-foot distance and at the same time supplies **¾ of its heated air to the interior space**

where it is not required. (Added burden on the cooling system) This wastes ¾ of the heating and requires additional energy from the cooling system.



Low bid variable volume system design

Guess what, slot diffusers are more expensive and there are additional ductwork costs to supply HVAC all away to the skin/perimeter of the facility. We have the low bid design build contractors to thank for this.

That's all for now and, look for my next articles.

- The stupid minimum position air flow and alternative solutions.
- The bad apple VAV zone and poor indoor air quality?
- Maybe there's a way to get rid of the energy wasting reheat *(cooling it down to heat it up*) process?
- Why motion detectors for lights, pneumatic controls and VAV systems don't work.
- Air-conditioning in computer IT rooms. Is that water dripping on our computer equipment?
- Building pressurization and the stupid sequence they keep using.
- I did the energy calculations told the building owner he would save, but he didn't save energy and money that I calculated. He was pissed off! What happened?
- Minimum position in VAV systems is causing lawsuits and/or allowing tenants to move out. When more people learn about poor air distribution and indoor air quality this could be a major incentive to upgrade their existing pneumatic systems.
- Big data, analytics, the cloud, Internet of things. Very exciting, but keep it simple stupid. Accurate, pertinent and additional data is required. Garbage in = Garbage out
- Building occupants or my grandkids won't turn the lights off. Why? No accountability?

- Mixed air economizers are typically screwed up. Why are 80 to 90% of these systems defective? They bring in fresh air, save energy and reduce the mechanical burden on the expensive cooling systems.

- The secret to intelligent energy-saving decisions when you don't know how much your mechanical equipment and components cost to operate.

- I Hate My Old Pneumatic Control System.

- VVT systems similarities and differences. Two position good/modulation bad?

It's time for my nap or my martini I forget! Oh well, I'll do one or the other. Maybe both?

About the Author

George Fincher, the old pro is currently retired from a career that started as Application Engineer, Robertshaw Controls in 1971. Owner of Energy Controls Co for 32 years. Inventor of the Patented DDC Control the **ecWizard.**