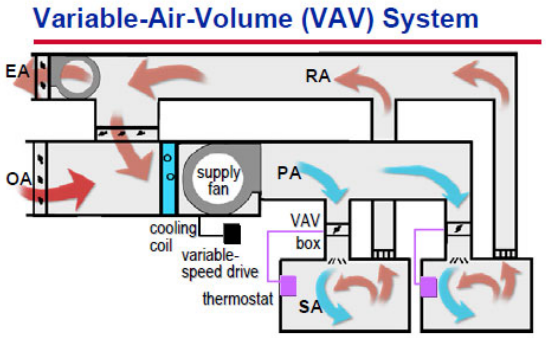
VAV Design and Controls Engineering

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.

One of the most important requirements besides programming skills and control functions is understanding systems. HVAC systems or the industrial process. That's right you must know what you're controlling and how to control it!



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.

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.

Why do I mention these two guys, because they were the smartest controls people in the nation in the late 60s and 80s? They were inventors with several patents and they changed the way controls were distributed in the nation and the world. The twin brothers also had a major impact on the design of VAV system and controls.

In 70s, if mechanical contractors wanted controls, the controls manufacture's basically said "sure a technician will come out and install". If you wanted just the controls, it would take months to get your controls.

The Ginn Brothers started training, designing, manufacturing and distributing directly to mechanical contractors and building engineers. This was the start of control distributors, before this you had to go through the manufacturers like Honeywell, Johnson etc.

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. they were 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 controls. Keeping their VAV designs in-house gave them the competitive edge 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 so to keep their secret they installed their own controls.

The secretive design of the original VAV system is why the VAV system of today is so misunderstood. There are thousands of systems that have missed basic concepts of the VAV system. If you interview the building 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 inferior system.

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 heating/cooling double duct systems. They had no training or experience with the **secretive VAV concept and design**.

The Original Design Theory of VAV Systems

The engineering theory of the VAV system is based on supplying heat/cool only to the skin or perimeter of the facility. With lighting, people and plug loads providing heat to the interior, so in theory cooling only was required for the core of the facility. Morning warm-up would provide heat in the morning prior to occupancy than the heat would be completely turned off.

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 like baseboard heaters etc. but they all protected against the sun and cold from outside. Very little heating was required and only the foot of space (skin load) to the perimeter was conditioned.

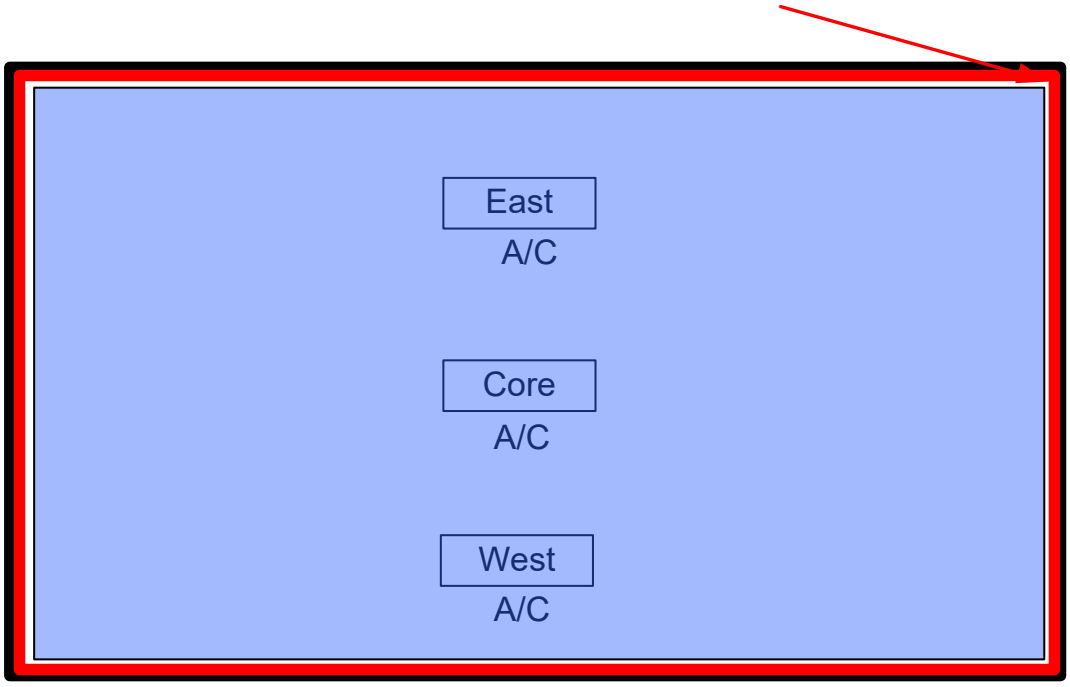
Three AC systems provided cooling. Example; East, West and Core AC Systems.

Morning warm-up consisted of the interior VAV boxes opening 100% until the return air temperature heated too setpoint.

At time of occupancy all the interior zones were cooling only and the VAV box damper modulated from completely closed 0% to 100% open. Indoor air quality was introduced through the perimeter systems with common central returns.

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

2,3 or sometime 4 Perimeter HVAC Systems



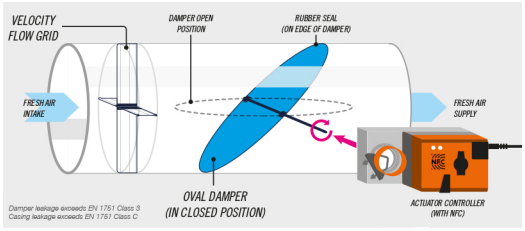
Original variable volume system design

One of the major mistakes is that the AC units will serve individual floors. As an example a three-story building would have one AC unit for each floor. This deviates from basic HVAC engineering principles.

Another common mistake is when a thermostatically controlled zone is trying to control interior and exterior conditions.

Main HVAC units and zones must have equal load conditions.

The birth of the minimum position air flow

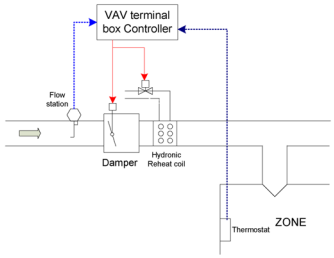


Indoor air quality was and still is a serious problem in the industry.

Before the introduction of VAV box minimum position. The perimeter systems were 100% outside air that was utilized during occupancy and full return air in the unoccupied warm-up period. This require larger capacity heating and cooling, central returns and expensive ductwork. In the summer, night purge with 100% outside air would exhaust the toxic chemicals thoroughly prior to occupancy.

In 1980's the consulting engineers introduced minimum flow of air into the condition space without any temperature control. There was no way of stopping a minimum amount CFM from entering the conditioned space. The amount (CFM) of minimum air flow was calculated to slightly cool the heat generated from the lights within the controlled zone.

Unfortunately, people would turn off their lights and the temperatures would drop dramatically from the minimum cold air flowing constantly. Once they returned to their office or conference room it was impossible to get warm. The service technicians and building engineers started turning the minimum position completely off.



Back to the reheat system.

To make minimum position work the consulting engineers introduced reheat (*cool the air down, then heat it back up)* 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 minimum amount of air was increased to 30% to 50% when the thermostat reached its setpoint for cooling.

The perimeter of your building!

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?
The same basic principle applies to your commercial building.

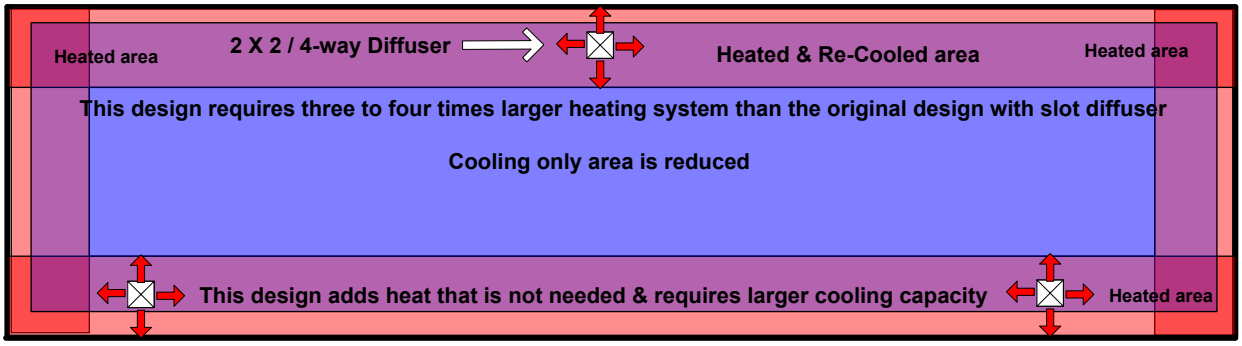
No diffusers by the windows, is a *common problem* in low bid commercial facilities. Windows allow the heat from the sun and cold to penetrate the condition space.

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

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 often not required** (added burden on the cooling system). This wastes ¾ of the heating and requires additional energy from the cooling system.

Several buildings built in the 1980s would have to start their heating system extremely early because of the undersized heating system. Heating systems with slot diffusers or baseboards did not require as much heat as a four-way diffuser 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 contractors to thank for this.

About the Author

George Fincher, the old pro is currently semi-retired from a career that started as Application Engineer, Robertshaw Controls in 1971 https://www.ecwizard.net/about

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