Lawsuits and/or tenants breaking their lease

The following story was told at a roundtable discussion (mechanical contractors MCA) in San Antonio, Texas. Around 1998

The tenant was downsizing personnel and was stuck in a long term lease. They were meeting in a conference room when the discussion of breaking the lease was brought up. The heating and air-conditioning was never really satisfactory but tolerable. It was an older building and mechanical breakdowns were more frequent than the owner and tenants would care to have but not enough to protect the lease.

Because the HVAC was not a bright spot with the occupants, that led to discussions that finally led to a lady (bookkeeper) that was constantly complaining about headaches and not feeling well when she was at work. Her headaches seem to disappear when she was not at work.

The tenants had a friend in the HVAC business that came out and inspected the system. He immediately brought out his air balance cone and found only 10 CFM of air flow in the bookkeeper's office. The office temperature was 76° and she was comfortable even with her sweater on. He then measured all 4 offices on the zone. He noticed that the zone closest to the VAV box received about 75% of the minimum airflow of the entire zone. The service contractor also found that the thermostat was located in the office that was closest to the VAV box. The temperature was 71.5° and the setpoint of the thermostat was 72°. This forced the zone to stay in the minimum position longer because the office with the thermostat received the greatest portion of minimum airflow and was maintaining the its room temperature. The majority of the air was taking the path of least resistance and the lady at the end (duct run) of the zone was an unhealthy environment.

This was all the ammunition that the tenant and attorney needed. A simple letter basically stating that the airflow in the facility was not equal and could cause health problems. The building owner was not able to guarantee adequate air flow to the tenant and they were able to break their lease. I'm not privy of any lawsuit that the bookkeeper may have filed against the facility.

The moral of the story is, with the old pneumatic control system the building owner could not protect the occupants to industry health standards. If the building had a DDC control system, (ecWizard) they could have utilize an airflow sensor and possibly a wireless IAQ sensor. Verifying equal airflow distribution and adequate air change within the breathing zone. The DDC control system could also monitor zone conditions and adjust equipment sequences to increase airflow through out of the HVAC zones equally.

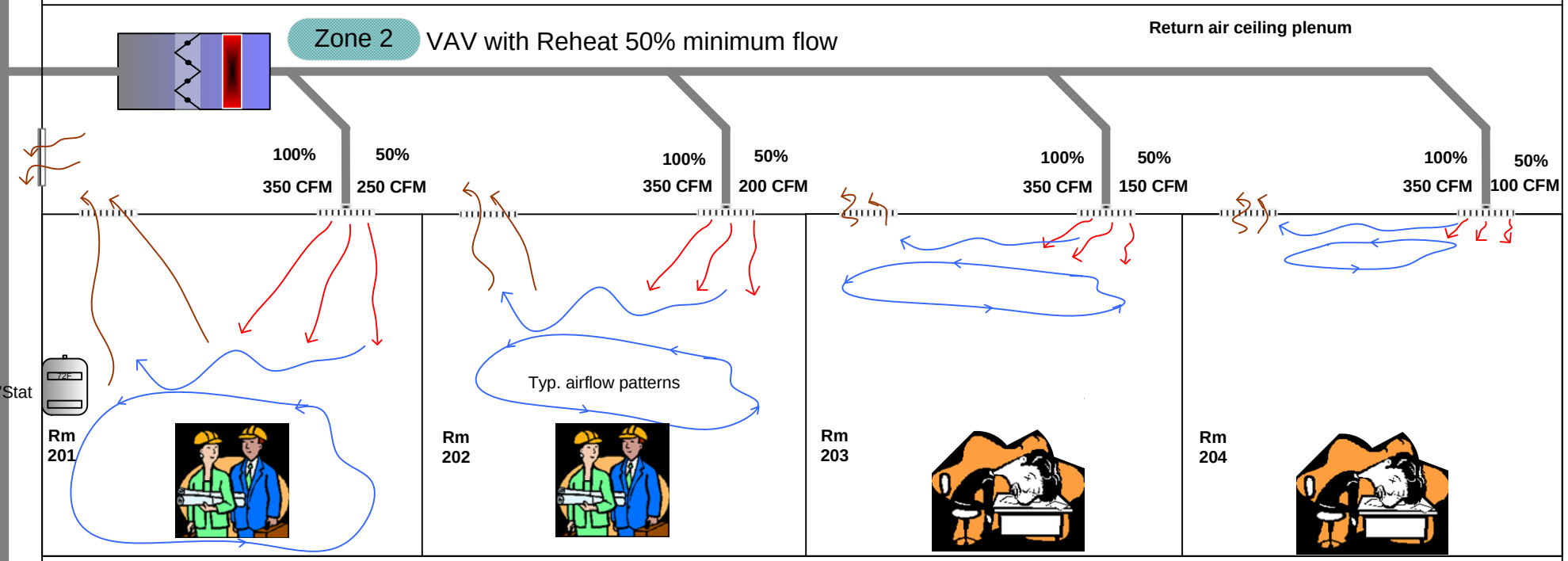
We listen to the building owners and they need support with the health of their occupants, protection from lawsuits and their tenants walking out on their lease.

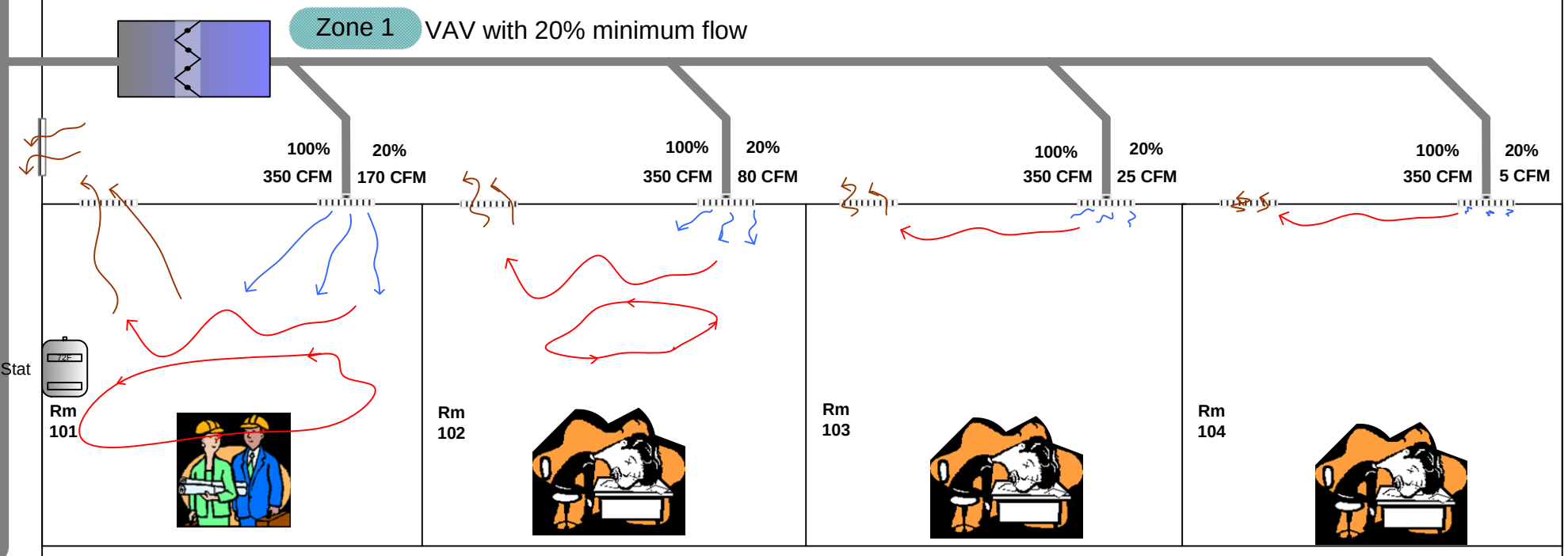
About the Author

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

I for a better understanding please read the following.

Indoor air distribution problems with minimum position air flow





IAQ and comfort problems associated with minimum position air flow in VAV systems.

The main purposes of the buildings HVAC (Heating Ventilating Air Conditioning) is to provide healthy and comfortable environments for human activities. The building should not cause harm to its occupants.

Reported problems of poor indoor air quality, and the threat of litigation is foremost on the minds of many people in the commercial building industry.

The significance of indoor climate for health and comfort has been emphasized. EPA studies of human exposure to air pollutants indicate that indoor air levels of many pollutants may be 2-5 times, and occasion more than 100 times, higher than outdoor levels. These levels of indoor air pollutants are of concern because it is estimated that most people spend as much as 90% of their time indoors. Good indoor climate decreases the number of illnesses and sick building syndrome symptoms, and improves comfort and productivity. The occupants are too often unsatisfied with the building's HVAC. Complaints concerning VAV systems in buildings in respect of health and comfort are common all over the world.

Over the past several decades, our exposure to indoor air pollutants is believed to have increased due to a variety of factors, including the construction of more tightly sealed buildings, reduced ventilation rates to save energy, the use of synthetic building materials and furnishings, and the use of chemically formulated personal care products, pesticides, and cleaners.
http://www.ehso.com/indoorai.htm

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) ventilation standards provide a minimum of outdoor air per person. (See ASHRAE Standard 62)

Variable air volume (VAV) systems are the most popular systems in facilities over 40,000 square-feet and up. The VAV system controls room temperature with a damper that varies the air volume via the room thermostat. As the room temperature drops below the setpoint of the thermostat a minimum CFM (cubic feet per minute) control bypasses the thermostatic control and maintains a minimum airflow to the conditioned space. The CFM control prevents the damper from shutting off completely. The room thermostat is not incorporated in the sequence of minimum position.

Most problems with minimum airflow are associated with the pneumatic VAV system. Lack of communications with the primary controls and antiquated zone controls limit the functionality. There are solutions to the following problems but they involve DDC control of the zones and primary mechanical equipment. **(See indoor air solutions and recommendations.)**

The attached drawing shows a typical VAV zone. Zones which utilize a plenum after the VAV box and provide a single duct per diffuser provide improved distribution in low air flow conditions. Unfortunately, most systems utilize a more economical ductwork configuration as shown in the drawing.

Basic issues:

Ventilation air should reach the breathing zone of the rooms as soon as possible after entering the room. This does not allow any short circuiting of ventilation air flow to the return opening, and minimum air change efficiency. As seen in the attached drawing system air without the proper velocity short circuits across the ceiling directly into the return air grill.

The minimum position does not provide ventilation equally throughout the conditioned space. **Proper indoor air quality is required for everyone**, **not just for the people positioned strategically within the zone.** If too little outdoor air enters the breathing zone, pollutants can accumulate to levels that can pose health and comfort problems.

"Thermal comfort and effective contaminant removal demand that air delivered into a conditioned space be properly distributed within that space. Poorly distributed air causes odor transport, stagnant areas, or short-circuiting." http://www.epa.gov/iaq/largebldgs/pdf_files/appenb.pdf

When controls are in minimum position, cold air is supplied without regards to room temperature because minimum position overrides the control of the room thermostat. Supplying cooled air into the condition space without regard to temperature conditions has been a concern for building engineers and service technicians for years. Eventually, the engineering community went back to the reheat design allowing the VAV box to close to approximately 50% - 30% flow. In double duct systems, the non-temperature control minimum airflow will allow the hot deck to open to compensate for the minimum airflow over cooling the zone.

Several types of VAV boxes are used in the industry. From double duct box, fan powered etc. all using various variable air volume techniques. For simplicity, this paper discusses only two types, as shown in the attached diagram.

A zone operating at the minimum position causes temperature stratification throughout the zone. Unbalanced air distribution and temperature complaints are often the results of the zone that continues to operate in its minimum position. This is a common problem when the supply air temperature from the main system is set too low and in mild load conditions. There are some zones that are constantly in the minimum position do to a variety of circumstances. This could be very serious health hazard to the unfortunate person that has air distributed below ASHRAE Standard 62.

Cooling only VAV zone

(See attached drawing Zone 1) This is the most vulnerable type of zone that incorporates the minimum position air flow. Once this zone drops below the setpoint it must rely on the lighting, plug loads and people to heat the condition space. Unfortunately, the people, plug loads and lighting are not always on. Occupancy, lighting and plug loads can vary.

The CFM minimum position setting is based upon the constant lighting heat load and ASHRAE Standard 62. It requires the lights to stay on preventing the occupants or motion detectors to turn lights off in unoccupied areas, such as conference rooms or offices that are occupied later in the morning. **The minimum airflow continues without regards to temperature and occupancy**. When the lights are off the zone will eventually drop way below the occupant's comfort conditions.

After numerous complaints, most building engineers and service technicians simply adjust the CFM minimum position setting to 0 CFM or close off 100%, allowing the thermostat to take control of the zones temperature conditions. There are alternatives to this unhealthy adjustment that requires DDC control and monitoring.

The diagram shows the popular worst-case scenario with the cooling only zone. The diffuser that is on the end of the ductwork will sometimes receive 0 CFM. The weight of air and restriction induces much of the air to dump out of the first diffusers, taking the path of least resistance.

VAV with reheat zones

(See attached drawing Zone 2) Zones that operate at 50%-30% of the designed full flow often complain of temperature problems from unbalanced air distribution. There are thousands of systems like this with complaints going to death ears. Millions of people hate going to work in uncomfortable conditions without proper air distribution and temperature stratification.

Cooling the air down and then re-heating it to maintain the temperature is an energy waste that should be eliminated as much as possible. DDC zone controls can be programmed and monitored to reduce the amount of reheat and maintain higher airflow conditions to the occupants. Supplying heat to the condition space then cooling that heat with expensive air conditioning is an old technology and energy wasting problem.

The reheat process requires boilers and pumps to operate through out the summer months with pneumatic zone controls without DDC monitoring.

50%-30% minimum airflow does not provide quality indoor air to all occupants within the zone. Most the air comes out of the first diffusers. Diffusers near the end of the run receive the lowest or no CFM. A great deal of the fresh air hovers across the top of the ceiling back into the return air grill bypassing the breathing zone.

Summary

VAV zones are air balanced at full flow and cannot be balanced any other way. The building owners and engineering community rarely know the airflow readings at minimum air flow conditions. Flexible ductworks, inexpensive type of diffusers often provide resistance adding to poor air distribution throughout the condition space when in minimum airflow.

The airflow leaving the supply air diffuser is designed to throw horizontally and in some part vertically. When the VAV system reduces to the minimum position, majority of the air will dump vertically. When the flow continues to reduce, it will then stay high in the ceiling and travel back to the return air grill. The supply air takes the path of least resistance dumping most the air out of the first diffusers located closest to the VAV box. A zone that can stay in the minimum position could possibly cause serious health problems to the occupants farthest away from the VAV box.

Typically, the thermostat is located under the return air close to the VAV box, this represents a **serious problem.** The minimum air comes out of the closest diffuser satisfying the thermostat and keeping the zone airflow at the minimum for longer periods of time causing unhealthy conditions at the end of ductwork due to **prolonged lack of air.**

The VAV airflow sensors lose significant amplification due to poor geometry of ducting and selection of the wrong VAV boxes. The ability to control accurately in low flow conditions add to the overall design issues inherent with minimum airflow.

Diffusers with perforated faces tend to have short throws at high airflow rates and may be unacceptable for VAV applications. Unfortunately, this is the most popular diffuser used in facilities throughout the nation.

Energy conservation is dictating that the facilities reduce the static supply air pressure in the main truck lines systems as mild conditions dictate. This affects the inlet pressure to the boxes and the ability to sense the pressure and control minimum CFM accurately.

As buildings age, debris and ductwork insulation often clog the pressure sensing tubes inside the box and ductwork. The sensing tubes measure the ductwork pressures required for control of the minimum and maximum CFM for each box. This reduces the accuracy of the CFM min/max controller. This is not a standard schedule preventative maintenance to clean out the small orifices of the sensing tubes. These CFM conditions are not monitored by pneumatic control systems and there's no historical data to show the normal conditions.

IAQ sensors are typically located under the return air grill which provides an average condition of the zone or at the thermostat location. IAQ sensors should be in the zone with the least amount of air flow in the minimum airflow conditions. See the attached drawing. The sensor would be in rooms 104 and 204. Wireless IAQ sensors communicating to the DDC system are the most economical solutions.

With the known air distribution/stratification problems inherent with minimum position it makes it **unfair** that not all occupants are receiving fresh air, comfort and not meeting IAQ code requirements. The health issues of the occupants must be taken seriously.

Issues with minimum flow are air and temperature stratification, short-circuiting and dumping of cold air out of the diffusers closest to the VAV box. Room temperature non-uniformities can result from insufficient flow at low loads due to low unit flow. If the airflow set point is below the working range of the velocity controller, the unit may cycle between closed and partially open, causing varying air distribution quantities.

DDC control systems can monitor airflows, and temperatures etc. Their diagnostic capabilities provide an extra margin of safety with indoor air quality.

Over-sizing of VAV terminals can lead to significant operational issues and generally results from the engineer using a cover your butt safety factor and increasing the size of the VAV terminal box. Additionally, over-sizing a VAV unit significantly reduces the velocity of the air passing the velocity sensor the same air flow as a properly sized unit, resulting in a velocity pressure that is below the sensing range of the VAV unit manufacturer’s velocity sensor.

Larger VAV zones represent additional problems with air distribution throughout the condition space. The larger the zones square footage represents a higher probability for poor indoor air quality, increasing the number of diffusers that fail to receive adequate air flow in minimum flow conditions.

What the building owners and engineering community think is happening with their HVAC system quite often is not the case. Service technicians and building engineers are often under a great deal of pressure to provide comfort for the occupants. Especially in the cooling only zones they will adjust the CFM controls minimum position to 0 psi or bypass it completely. This is well-known procedure within the service technicians and building engineers. Of course, doing this is against the indoor air quality designs and wishes of the building owner. This latent adjustment is quite often covered up in their service reports to the building owners. Monitoring the zones with DDC controls will expose this adjustments and temperature problems.

Another common error is running too much flex duct. It would be better to continue the rectangular duct to the last diffuser, then install short flex branches. The duct connections at the discharge end of the VAV box terminal have a major effect on pressure drop. Y-connection close to the discharge should be avoided. Because of the expense the wrong way unfortunately is the most economical and typically used.

Improper inlet connections and the arrangement of the duct to the VAV terminal inlet affect both pressure drop and control accuracy. Improper connections create turbulence at the inlet. This makes

it difficult for the sensor to measure airflow accurately. The best practice is to use straight duct at the inlet the same size or larger than the inlet to VAV Box.

No matter how accurate the ductwork drawings are from the engineering community, it's almost impossible to inspect all the ductwork, plus it's hidden in the ceiling causing problems with air distribution and indoor air quality.

In many cases, controlling moisture in the schools and office environments is the key to preventing mold growth in the conditioned space. It can be a lot less expensive than mold litigation and remediation. Moisture control with desiccants, cooling coils, along with building pressurization help prevent mold in humid environments. Negative air infiltration can possibly bring in so much moisture from the outside air, that a building can reach a saturation point. Positive pressurization should be maintained and monitored. (.03" to .05") most facilities do not have building static pressure sensor because of the cost of running the cable. Wireless sensors provide an excellent opportunity.

"The pattern of unequal zonal distribution need not be a problem where there is significant mixing between zones, such as in open plan offices that span both the perimeter and the core zones. However, where air mixing is interrupted, as may be the case with closed offices, this deficiency in air delivery to the core zones could be a problem. The problem would be partially mitigated by the fact that both the perimeter and core zones share the same return air stream, but this is not likely to be significant especially if the outdoor air delivery to the air handler is also inadequate." http://www.epa.gov/iaq/largebldgs/energy_cost_and_iaq/project_report3.pdf

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6.2.2. Zone Air Distribution Effectiveness The zone air distribution effectiveness shall be no greater than the default value determined using tables 6-2.
6.2.7.1.3 The ventilation system shall be controlled such that at a steady state it provides each zone with no less than the breathing zone outdoor air flow for the current zone population.
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Indoor air solutions and recommendations

Please review the paper titled, IAQ and comfort problems associated with minimum position air flow in VAV systems. The paper discusses a series of problems with air distribution of minimum position with a VAV system. We recommend reading this first.

Variable air flow is an unhealthy air distribution problem that we have become accustomed too.

- Low cooling supply air temperatures require less air to maintain the temperature.
- Higher supply air temperatures require more air to maintain the temperature in the condition space, this is an important concept to understand.

Supply Air Temperature Reset

Raise the cooling supply air temperature which opens the zone dampers increasing airflow to maintain room temperature conditions.

All the zones within the fan system must be as of equal loads as possible. If several zones require lower supply temperatures and have higher heat loads, (rogue zones) then additional ductwork and or VAV boxes should be installed to compensate for the higher load requirements. Once these repairs/upgrades are completed then the supply air can be increased to its maximum increasing airflow throughout the breathing area.

Quite often the VAV zone will stay in its low minimum airflow position for hours, this is unhealthy to the occupants that are at the end of the duct run. Can be identified by a 2 to 3°F temperature difference from the first diffusers in the last diffusers of the duct run.

Temperature Controlled Minimum Pulsed (100%) Flow (VAV)

It's better to have the zone DDC control completely shut off the zones air supply which would raise the temperature in the condition space. With the higher zone temperature, the VAV box should be allowed to quickly modulate full open providing adequate air distribution throughout the zone.

.5°F/.25°F setpoint fluctuations can be utilized to induce full flow conditions. Software timers provide limitations to the shutoff times. DDC control learns the rate of temperature increase and shuts off the air damper just prior .5°F/.25°F to reaching the setpoint. Shutting the air off for 15 minutes will not affect the health of the occupants. It's better to have a good flushing of air throughout the zone providing indoor air quality to everyone. Temperature controlled minimum pulsed zone sequence, we can monitor the air change within the breathing area and validate that they are receiving adequate air change. Added comfort is provided because we have eliminated temperature stratification from an adequate air distribution. The above is similar with the heating sequence.

Mixed Air Economizers

Special care should be taken to eliminate the mechanical cooling from starting to soon and utilize the full outside air as long as possible. In the morning outside air can provide cooling supply air temperatures as high as 60°/65°F Monitoring the temperature of the economizer system and comparing the supply air to the outside air provides valuable diagnostic information about return air

damper tight close off and or leakage of exhaust or return air into the mixed air plenum area. The 55° F outside air should equal the 55°F supply air temperature. The supply fan can increase the temperature of the air by 1 or 2°. Certain parts of the country have humidity and mold concerns that must be monitored carefully. DDC monitoring of all zone temperature conditions, mixed air, outside air and supply air we can keep the mechanical cooling off as long as possible utilizing fresh air to its maximum.

When the outside air dampers are fully open and the mechanical cooling is off this is an excellent time to be flushing the complete building out with fresh air. The main supply fan static pressure can be increased to help maintain zone temperatures. Problems areas may require additional diffusers and ductwork to maintain comfort levels and prevent noise and drafts.

Indoor air quality can be improved by:

- Monitoring zone conditions that communicate with the primary DDC controls.
- Equalizing the load conditions throughout the VAV fan system.
- Maintaining quality economizer system by monitoring conditions continuously.
- Utilizing outside air to its fullest and keeping the mechanical cooling process off as long as possible.
- Higher supplier temperatures by monitoring zone temperatures.
- Maintaining properly functioning zone controls by utilizing DDC diagnostic monitoring opportunities.
- Night purge cycles efficiently flushing out the facility in the summertime.
- Do not allow zones to stay in the minimum position for any length of time.