Analysis 2

Variable Air Volume vs. Constant Volume for Laboratories

Background

Incorporating sustainability into any building is becoming increasingly important. One key to a sustainable building is reduced energy use, and a good method for achieving this is a Variable Air Volume (VAV) system. The major advantage of a VAV system is the energy savings that result due to reduced load operation. The system varies the amount of air supplied to specific areas of a building based on demand. The energy crisis of the 1970s significantly advanced the development of these systems. Rather than adjusting the temperature of incoming air to achieve desired conditions, a VAV system alters the amount of air entering or leaving a space. VAV systems are now used extensively in modern office buildings, but when designing for laboratory spaces several important issues arise that must be considered. The Forest Resources building utilizes a VAV system for the offices and classrooms, but the lab areas are designed with a constant volume system. A large energy use reduction could be seen by installing a VAV system for the laboratories as well.

Problem

Variable Air Volume systems do have some disadvantages whether used for laboratories or simple office buildings. Many VAV designs neglect the maintaining of reasonable building pressures, which can cause excessive infiltration or exfiltration of air. This problem is especially pertinent to laboratory design because labs are required to meet guidelines for maintaining negative pressure in order to eliminate the exfiltration of chemicals into the surrounding areas. Laboratory ventilation is provided by a once-through HVAC system, meaning 100% of the air supplied to the lab is exhausted and therefore must be replenished from outdoor air. This outdoor air must be fully conditioned, usually 24 hours a day, year round. This fact causes

the high energy demands for laboratories. Utilizing a VAV system for laboratories is possible and has been used in many buildings across the country, although it can be more difficult and special considerations are needed.

Solution

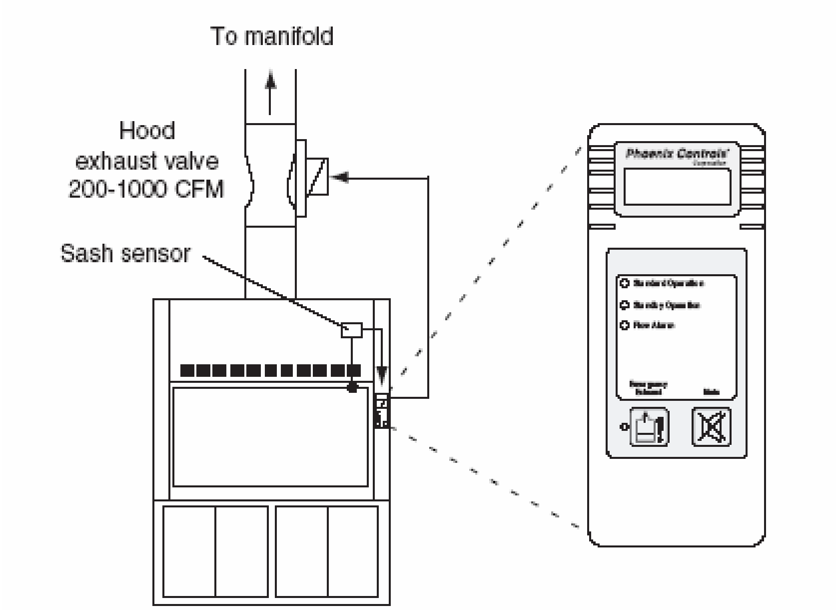
Variable Air Volume technology has been adapted to the laboratory setting to provide sophisticated exhaust and supply tracking systems that dramatically lower energy consumption while meeting all ventilation requirements. A laboratory fume hood has a movable sash and the containment of harmful fumes is maintained by providing constant air flow through the sash opening. If the sash is fully open, more air is required to maintain a minimum safe airflow than if the sash is closed. The most important part of a VAV system for laboratories is controlling the discharge of air through the hood. A VAV laboratory hood exhaust system will automatically vary the airflow based on the position of the sash. The exhaust system also needs to be interconnected with the supply air system in order to maintain space pressure and ensure adequate makeup air for the hood under all conditions.

In order to control the air being exhausted and supplied a variable frequency drive (VFD) may be used to alter the fan speeds for large parts of the system which service multiple rooms, but individual runs of duct will need to have air flow control valves to control the flow to individual rooms. Valves that control the exhaust flow

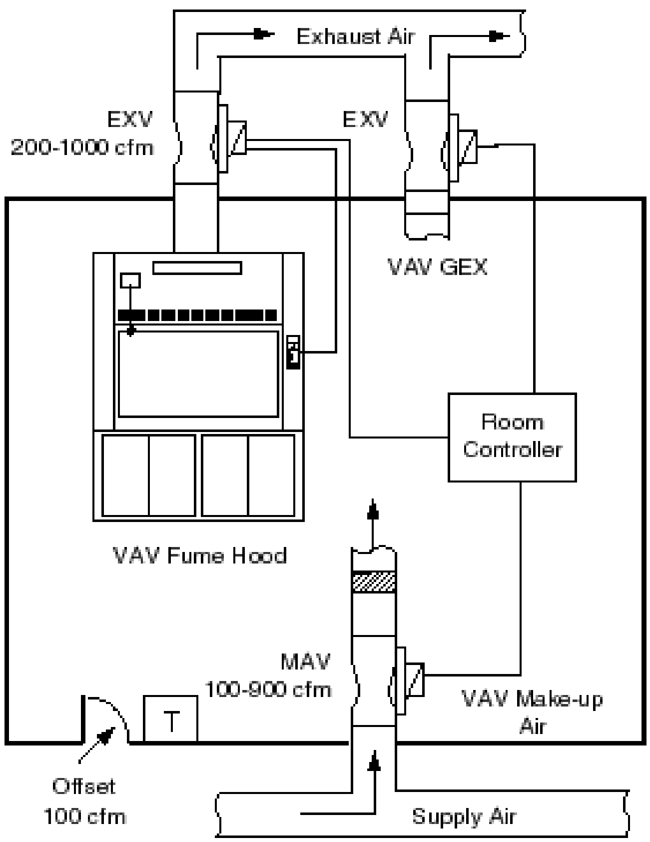
from fume hoods and the air supplied to individual rooms are a necessary part of the VAV system. The valves on the exhaust system will also need to be wired to a monitoring device in order to determine sash position and required airflow. Even more control wiring is needed to link the exhaust air valves with the supply valves and

VFDs to maintain proper pressure. If more air is supplied to the room than is exhausted, the lab will be under positive pressure and air will leak out into surrounding areas. Phoenix Controls Corporation is the recognized leader in the design of airflow control systems for VAV laboratory uses. Phoenix Controls produces an entire line of control valves used for both the exhaust air and supply air. Several models of their Accel II Series valves are pictured on the previous page. They are available in many sizes and finishes and they're unique ultra-quiet conical design reduces or even eliminates the need for sound attenuators.

After the control valves for a VAV system are installed monitoring devices and control wiring must be installed. These typically include a thermostat, humidity meter, and pressure sensor for the room, to control the supply air, as well as a fume hood monitoring device, to control the exhaust air. Phoenix Controls has several models of monitoring devices for rooms and for fume hoods. The diagram below shows the arrangement of a fume hood, with typical exhaust valve and monitoring device. The monitoring device will calculate the face velocity needed for proper exhaust based on sash position and will relay this information to the exhaust valve and the supply valves.



These monitoring devices cost around $400 each depending on the model. When considering the cost of a VAV system, the valves and monitors must be considered as well as the additional control wiring needed and usually a central monitoring program that oversees the entire system from a computer network. The researchers in the lab must also play an integral role in saving energy by closing the fume hood sash when not in use. If the sash is kept open at all times, even when not in use, the flow air will not be reduced and the VAV system would function like a typical constant volume system with no energy savings. The energy savings for VAV fume hoods compared to conventional constant volume hoods is an average of 80% reduction in exhaust fan energy. These savings assume that the hoods are closed when not in use. The following diagram shows the arrangement of control valves and wring needed in a typical laboratory VAV system.



Another difficulty in implementing a VAV system for laboratories is the need for conditions in the lab to remain constant for certain experiments. Typically if a room is unoccupied the air flow rate will be reduced causing the temperature and humidity to fluctuate. There are also certain hours of the day where the air flow is automatically reduced. This is known as a nighttime setback. When scientists leave experiments running overnight or for extended periods of time, they often require the conditions in the room to remain constant. In order to maintain constant conditions in a laboratory, an override switch can be installed that would override the VAV system and keep the conditions at a normal level. Several problems arise when using a nighttime override switch, however. First and foremost, the researcher must remember to use the switch when they are leaving for the night and have an experiment running. This task can become bothersome for the researchers and often they will keep the system in permanent override so that they do not need to use the switch each time it is needed. This practice of leaving the switch on or even taping it down permanently completely defeats the purpose of the VAV system and energy costs would not be lowered.

The initial cost of utilizing a VAV system appears to be higher due to added air valves, VFDs, monitoring devices, and control wiring, but much of the equipment needed for a constant volume system, such as the air handling units may be reduced in size, saving money on the initial cost. Even when the initial cost of installing a VAV system is greater than that of a constant volume system, the difference can easily be recovered in energy savings throughout the life of the building. Using a VAV system in laboratories can reduce the energy costs as much as $2 / square foot. This represents at least a 20% savings on electricity, as the typical use for a laboratory is $5 – $10 / square foot per year. Another method for determining the cost of a VAV system versus a constant volume system is to perform a life cycle analysis. This takes into consideration the initial cost of the system as well as energy and maintenance costs over a fixed period of time. A detailed life cycle cost analysis can be found in Appendix A. When evaluated over a 20 year life span, the VAV system

proves to be a better investment, and the 50 year life cycle analysis shows that the longer the system is in use the greater the savings become, relative to a constant volume system.

Conclusion

As discussed earlier, sustainability is an important design feature of many new buildings. One way to design a more sustainable building is to reduce the energy usage. A Variable Air Volume system is an excellent way to reduce usage. In almost all situations a VAV system will save the owner money. Initial costs will most likely be higher, but a properly designed, maintained, and used VAV system will provide savings on energy costs over its lifetime. For a laboratory building, the equipment and controls needed will be more sophisticated, but the technology does exist to provide a well functioning system. The designer must keep in mind the air flow and pressure requirements of the space, but these should not jeopardize the use of a VAV system. Installation of the VAV system will take longer and provisions should be made in the construction schedule for the added equipment and control wiring needed. For the Forest Resources building, at least half of the building is already utilizing a VAV system, so converting the lab spaces to be VAV would be a likely choice. This will not only reduce the costs associated with energy use, but it will help the building to obtain additional LEED credit points. When using a VAV system, there are many additional features that can be added to increase the energy savings. Using an enthalpy wheel to preheat the incoming air from the exhaust air is just one option, but all options should be evaluated to determine their savings versus their initial cost. In most cases these upgrades prove to save energy over the life of the building.