

BUILDING EFFICIENCY AND INDOOR AIR QUALITY- YOU CAN HAVE BOTH

Gerald J. Kettler, P.E., REM
President
AIR Engineering and Testing, Inc.
Dallas, Texas

ABSTRACT

Providing ventilation for acceptable indoor air quality per ASHRAE Standard 62-1989 does not require large increases in utility costs. Building efficiency does not have to be sacrificed for a healthy building. The ASHRAE 62-1989 requirement for office ventilation is 20 cubic feet of fresh air per occupant. However, the Standard also allows various controls strategies to achieve the same result. This paper will describe the methods and application of several of these options. However, due to length restrictions, systems design criteria and comparisons will not be addressed. The simplest and most commonly used method is reducing the fresh airflow based on building occupancy, or demand control ventilation. This is currently done with carbon dioxide sensors controlling inlet dampers or fan control systems. As the people load varies causing changes in carbon dioxide level, the controls can vary the amount of ventilation air entering the building. A second method is removing the contaminants with added or special filtration. This allows more air to be recirculated but has specific limitations. Filters can remove large particulates and some chemical contaminants by changing the filter media. However, a minimum amount of fresh air, approximately 20% to 30% of the full 20cfm per person, is still required to remove the carbon dioxide and other contaminants not removed by the filters.

Another group of methods is energy recovery systems including; sensible heat wheels, desiccant heat wheels, heat pipes, and run around loops. These methods can be used on some packaged equipment but is normally provided on makeup air units and central air supply systems. These built up units offer opportunities to combine heat recovery, special filtration, humidity control and demand control operations.

INTRODUCTION

The energy crisis of the 1970's changed building design and construction. Air leakage was reduced. Outside air ventilation codes were reduced. At the same time, new chemicals and materials were being introduced to the building process. All of these factors resulted in the creation of contaminant levels high enough in many buildings to negatively impact the health of the occupants. Thus the indoor air quality industry was created.

Two solutions were developed to alleviate the indoor air quality problems; remove the source contaminants, and increase ventilation with clean outside air. The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) revised their Standard 62, "Ventilation for Acceptable Indoor Air Quality" in 1989 to increase the outside air supply rate to increase ventilation and flush contaminants from the buildings. Unfortunately heating, cooling and dehumidification of this outside air supply to maintain comfortable interior conditions can increase the utility costs for the building. An unnecessary battle has developed between ventilation rates and utility costs. This paper outlines several methods that can be used to limit energy costs by reducing air flows and recovering energy from air exhausted from the building. Due to length limitations, only basic systems will be discussed.

VENTILATION REQUIREMENTS

ASHRAE Standard 62-1989 offers two options for providing required ventilation. The prescriptive method requires a specific volume of outside air be provided for each space occupant. For offices this is 20 cubic feet per minute (cfm) per occupant. For classrooms the rate is 15 cfm per occupant. The second option is the air quality method that requires the monitoring of air quality levels and providing ventilation air to maintain the minimum air quality levels. Because of the difficulty and lack

of standards in measuring contaminants this method is seldom used. When these new standards were implemented, the ventilation air requirements increased from 5 to 20 cfm per person in offices. In hot climates this increased the utility costs to cool this extra 15-cfm. In cool climates the heating costs increased.

There are several opportunities to reduce the energy cost and continue to provide good indoor air quality. The volume of air brought into the building can be varied to match the actual building occupancy. This is called demand control ventilation. Since the volume of air entering the building must match the air leaving the building, the energy can be recovered from the air leaving and transferred to the entering air. These are called energy recovery systems. Cleaning and filtering the recirculated air is also a method of reducing outside air demand.

DEMAND CONTROL VENTILATION

The human respiratory process produces carbon dioxide. This is a normal constituent of the air and can be easily measured. The outside air volume requirement is based on occupancy. So if the variations in occupancy can be determined, the ventilation volume can be changed to match. The respiratory rate and thus the production of carbon dioxide are fairly constant for a uniform occupancy. Using this fact, carbon dioxide detectors can be located in occupied spaces or return air paths to send a signal to a control damper or fan speed control to vary the ventilation air rate. Interpretations of ASHRAE 62-1989 (IC 62-1989-27) allows this method with the provision that the ventilation rate not go below a minimum required for the removal of building and materials contaminants.

ASHRAE Standard 62-1989 uses 1000 parts per million (ppm) of carbon dioxide as the action level at which added ventilation air is required. This is a little misleading in that the outside air carbon dioxide level is assumed at about 350 ppm. This assumption is often low for many areas in cities and near highways. Research by ASHRAE and others has shown that the normal carbon dioxide generation rate for offices, when matched with 20 cfm of ventilation air levels produces approximately a 650 ppm carbon dioxide level. Thus the level at which the sensor increases the outside air ventilation rate should be set experimentally for each building using this method. Alternatively, inside and outside air monitors can be utilized as a differential

function. The March 1998 draft addendum 62f to 62-1989 clarifies the problem of higher outside air levels of carbon dioxide by using 650 ppm as the differential level between inside and outside levels.

Many systems for monitoring and controlling outside air ventilation are currently available. Constant volume systems can utilize return air monitors and variable damper controls. Package units are available with these controls already installed in the unit. Variable air volume systems must use an air injection fan with volume controls to assure proper airflow rates. These fans can be controlled by variable speed drives. While current carbon dioxide sensors are fairly accurate and reliable, they must still be calibrated periodically.

Another type of common air contaminant is volatile organic compounds (VOCs). These are produced by vehicle exhausts, emission from some building materials, and some biological processes. Normal vehicle exhaust rates are normally diluted sufficiently and at a sufficient distance from the building to not have a direct impact on carbon dioxide levels. Building air intakes near truck docks, auto drop off and parking areas may bring in sufficient contaminants to cause serious problems. The outside air ventilation with clean air will remove VOCs as well as the carbon dioxide. Some manufacturers also offer VOC sensors to control ventilation, but these sensors are not universally accepted as being reliable at this time.

It should be noted that due to the vast number of potential contaminants, sensing carbon dioxide and/or VOCs will not necessarily guarantee good air quality. The office ventilation rate with clean outdoor air at 20 cfm per person has proved to be effective in most cases. However, a strong indoor contaminant source or dirty outdoor air may make other methods and controls necessary.

FILTRATION SYSTEMS

Air contaminants in buildings are a mixture of human effluents as well as chemical emissions from building materials. If the contaminants can be removed from the air, more of the existing air can be recirculated and less outside air is required. However, since carbon dioxide cannot be filtered out, a minimum quantity of fresh air is always required. This air quality method requires that the air handler filters remove a higher percentage of particulates and also chemical

contaminants that are not removed by normal low efficiency filters. This requires high efficiency filters and filters with carbon or other media for chemical removal. Several filter manufacturers have developed graphical methodologies for determining the new recirculated airflow rates. This is based on the filter efficiencies, types of known contaminants, and type of filter media.

ENERGY RECOVERY

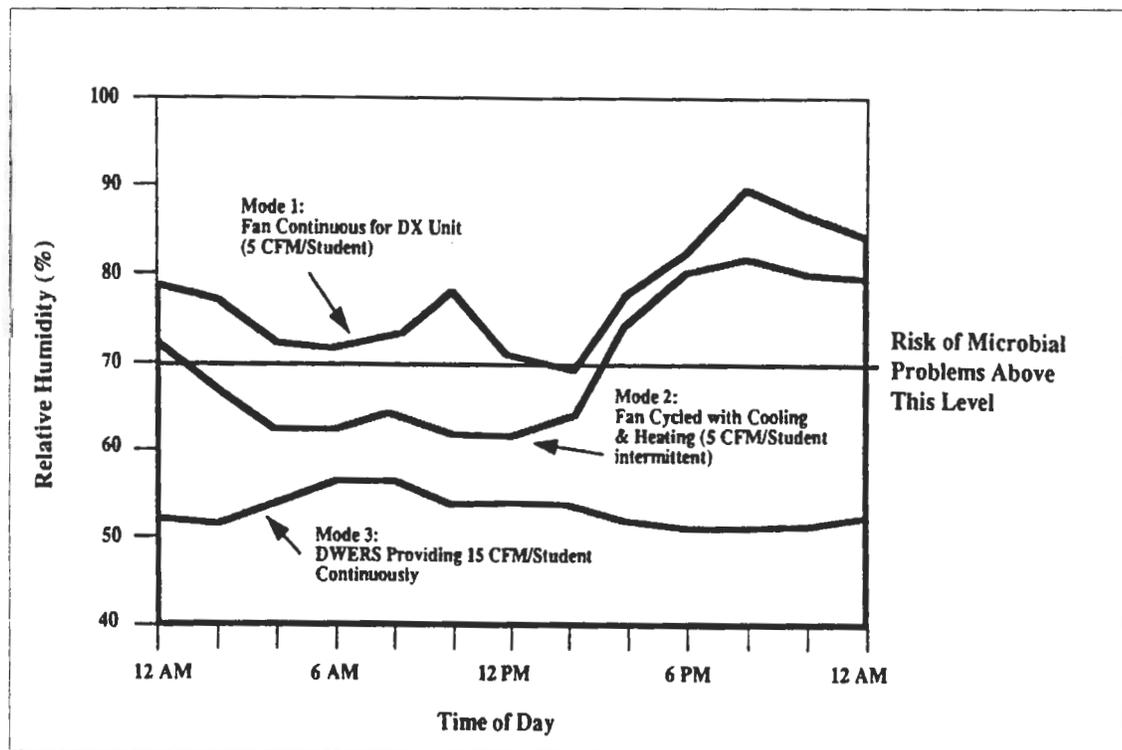
The comfort conditions in a building require that the temperature, humidity and contaminant conditions be controlled in a fairly narrow range. Since the contaminants are produced continuously from the occupants, building materials and outside sources, ventilation air will always be required. As new air is brought in it must be conditioned to meet interior requirements. The various energy recovery systems are designed to remove or recover the energy from the air leaving the building and transfer it to the incoming air. In humid climates the humidity must also be transferred or controlled to maintain proper interior conditions.

Heat Wheel Systems

The transfer of thermal energy between incoming and leaving air can be done by moving

the air through a mesh material to pick up the heat content of the exhaust air in the winter or the cooling conditions in the summer. The mesh material can then be rotated to the incoming air side of the equipment where the incoming air is tempered by contact with the heat transfer material. The simple transfer of heat energy is called a sensible heat wheel or transfer of temperatures. This transfer reduces the amount of energy required to raise or lower the temperature of incoming air by recovering some of the energy leaving the building.

A sensible heat wheel cannot assist in humidity control. To provide for humidity control the industry has developed a heat transfer wheel with a desiccant coating. This wheel transfers both humidity and temperature conditions between the incoming and exhaust air streams. This lowers the latent or humidity load on the air conditioning system in the summer and can also raise the humidity level in the winter time which produces better comfort conditions. In some climates it is also useful to use a gas heater system to assist the desiccant wheel energy recovery system (DWERS). The following figure 1 shows the benefit of this type of energy system.



The heat wheel systems require that the incoming and exhaust air streams go through adjacent chambers to allow the heat wheel to work efficiently. Care must be taken to assure that the mixing of the air streams outside the air handler is minimized to prevent contaminants from reentering the building. Filtration must also be provided to keep the heat wheel clean and efficient.

Heat Pipes

Another type of system used to recover energy from the leaving air is the heat pipe. In this system a heat transfer fluid is encased in a tube usually with heat transfer fins. The heat in the air evaporates the fluid and the vapor moves to the cooler end of the pipe where it recondenses and transfers the heat to the other end of the heat pipe. By placing the ends of the heat pipe in the incoming and exhaust air streams, heat can be transferred and recovered. These heat pipe systems are limited to sensible heat transfer and the heat pipe length is also limited so the air streams must be adjacent. Another common use for the heat pipe is in a reheat function for a dehumidification coil. Heat from the incoming air is transferred to the cooler air down stream of the cooling or dehumidification coil, thus saving energy. A complete system, in this case, would consist of a heat pipe system for sensible heat transfer between incoming and outgoing air streams and a cooling coil with a wrap around heat pipe for dehumidification.

Runaround Loops

If the ventilation air intake and the air exhaust locations are separated or distributed, it is necessary to utilize a piped water or glycol system with heat transfer coils to recover and transfer the energy. This system can be used to recover energy from distributed exhaust systems and building air relief ducts and transfer the energy to the incoming air by pumping the water or a water/glycol mixture to the air intake. This can be done as a retrofit to existing buildings. However, the disadvantage is the pumping energy and extensive piping required to move the heat transfer fluid around the building. It takes a fairly large temperature difference to justify the cost of installing and operating a run around heat recovery system.

COMMISSIONING AND TESTING

One of the most important factors in the efficient operation of heat recovery systems is that they are designed and operate properly. To assure the proper operation of all mechanical systems, a process known as commissioning should be utilized. Commissioning and functional testing is a process of checking the design documents to the owners intent, checking the installation quality, assuring that proper functional testing is conducted, and adequate training and documentation is provided to the facility operator. This is usually done by an independent professional commissioning agent. Without this testing there is no record of system performance for future reference and maintenance.

CONCLUSION

A sufficient outside air ventilation rates is necessary to provide a healthful indoor environment. The potential increase in energy costs to heat, cool and dehumidify the ventilation air can be greatly moderated by control systems and energy recovery. These options include:

- a. Demand control ventilation - reducing ventilation airflow to match the building occupancy levels using carbon dioxide and potentially VOC sensors to control dampers and ventilation fans.
- b. Filtration – cleaning and removing the contaminants in the return air to increase the amount of recirculated air suitable for use in the occupied space.
- c. Energy recovery systems – heat wheels, desiccant wheels, heat pipes, and run around loops to recover energy from the exhausted air. These are most applicable for new installations.

Energy simulation conducted in Florida (Davanagere, et. al) indicates that these methods can lower the increased energy costs from over 20 % for the increased ventilation to less than 5 %. Thus it is very feasible to increase the building air quality even in hot and humid climates without a large increase in utility costs. Care full analysis and design along with system commissioning is required to assure comfort and efficient conditions.

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