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Technical Services

APPLICATION ENGINEERING
BULLETIN Number # AE-005-05

TOPIC: Fundamentals Of Building Pressure Control And Ventilation

SCOPE & PURPOSE:

- This bulletin will introduce the reader to building pressure control, its importance, operation, control and various strategies used for pressure control.

CONTENT:

- The Need For Building Pressure Control

Since the 1960s the construction industry has been constructing buildings tighter and tighter in an effort to make our homes, offices and dwellings more energy efficient. Cracks have been sealed, windows weather-stripped, foundations tightened and windows installed that cannot be opened. Wall, ceiling and even floor insulation installed with vapor barriers to prevent moisture exchange. Summer heat gains and winter heat loss has been reduced significantly. However, these energy conservation steps also sealed in the building envelope preventing old stale air from being exhausted and fresh outside air from entering the envelope. In the past, normal air leakage seemed sufficient to replace the stale. Such is no longer the case.

The construction materials as well as the material used in the furnishings within the building often contain modern adhesives, glues, cements, varnishes, sealants and other compounds that off-gas into the air over time. Additionally, the occupants use cleaning compounds, soaps, glues, inks in printers as well as prepare foods. The compounds in wall coverings, carpeting, furniture and paints also off-gas resulting in contaminated air.[1] Furthermore, the occupants inhale this air, remove the oxygen and exhale carbon dioxide.

[1] These compounds are collectively called VOCs or Volatile Organic Compounds. VOCs have been directly tied to cancer, brain tumors, lung disease and many other illnesses. Authorities believe that many workplace absences can be attributed to poor IAQ and concentrations of VOCs in the indoor air.

This low quality air is often re-circulated throughout the structure by the heating and air conditioning system thus ensuring every occupant receives his or her share of poor indoor air quality (IAQ).

Building Pressure

Ventilation air is one of the primary methods of raising the indoor air quality.[2] Fresh outside air must be brought into the building to purge the building of the poorer contaminated air.[3] Replacing the indoor air with outside air on a regular basis is not only a good practice; it is often a health or building code requirement. Ventilation air is often stated as the number of times per hour that all the air in the space is replaced with outside air. Another method of stating or specifying the amount of outside air required is the amount of outside air in CFM per person in the space. ASHRAE has set recommended standards and local and state codes specify what is required. Some codes require the outside intake air dampers to be adjusted to maintain a minimum percentage of outside air to enter the building when the building is occupied.

Introducing outside air into the building thru a set of outside air dampers can create a new set of conditions which must be contended with. Consider the sealed building envelope as a sort of non-elastic balloon. Air brought into the structure causes it to become pressurized. Over pressurization can cause doors to the outside to stand partially open, can cause high velocity air to move through that opening and can cause paper and other items to be blown out the opened door. People entering the building thru the door will experience high velocity air striking them as if the wind is blowing. Additionally, the building can become so over pressurized that the cracks around windows "sing" with the escape of air thru the cracks. In more extreme cases, a window can actually be blown out of its frame and be sent sailing to the area below.

Air Pressure Measurement

It is desired to maintain an internal building pressure slightly higher than the pressure at the exterior of the building. This pressure is measured in fractions of an inch of water pressure. A typical inside pressure is usually in the range of .01 to .03 inches of water column pressure. This is a pressure differential with respect to the pressure of the outdoor air. Pressures are measured using one of the many available versions of manometers with a low range. Two common forms of manometers used to measure building pressure are the Magnehelic[4] gauge and the electronic manometer. Both instruments are useful for a variety of HVAC applications and should be a part of every technician's tool kit.

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[2] Another primary method of raising the quality of indoor air is the use of a well maintained filtration system.

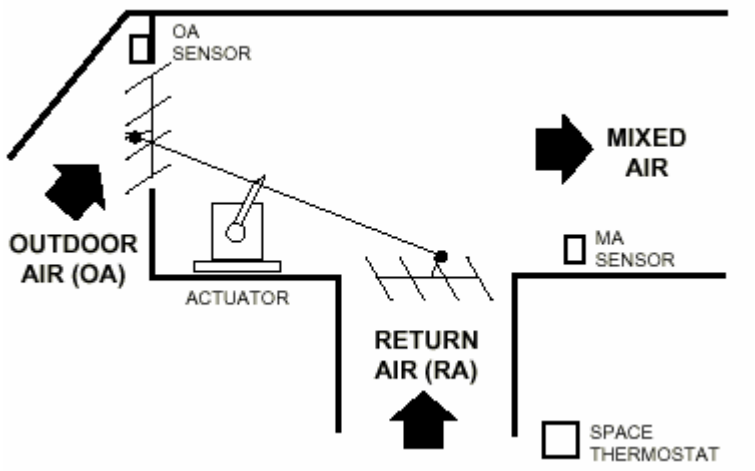
[3] Some object to the use of the term "fresh" when discussing outside air. It is noted that in some cases polluted outside air is hardly "fresh" however, the term fresh is a relative term and is simply used here to express the concept that the cleaner, newer, fresher outside air is being used to purge the less desirable indoor air from the building in an effort to improve the quality of the indoor air. Government surveys have determined that indoor air often experiences five or more times poorer air quality air than outdoor air.

[4] "Magnehelic" is a registered trade name owned by Dwyer Instruments, Inc.

Photos courtesy of Dwyer Instruments, Inc.

The photo on the left shows a Magnehelic gauge and the photo on the right a digital read-out electronic manometer made by Dwyer Instruments. The Magnehelic in the photo has a range of 0 to a half an inch. A gauge with a range of 0 to ¼-inch would be more accurate for our purposes. In either case, the instrument chosen must have a low enough scale to measure the small building pressure differential as compared to the pressure outside. Each instrument has two rubber hoses. To measure the building pressure (Often called building static pressure), one hose is placed outside the building with the other placed inside the building. One method is to utilize a mailbox slot sometimes cut thru a wall or installed thru a door. Always zero the meter prior to taking the measurement.

- Power Exhaust Solutions



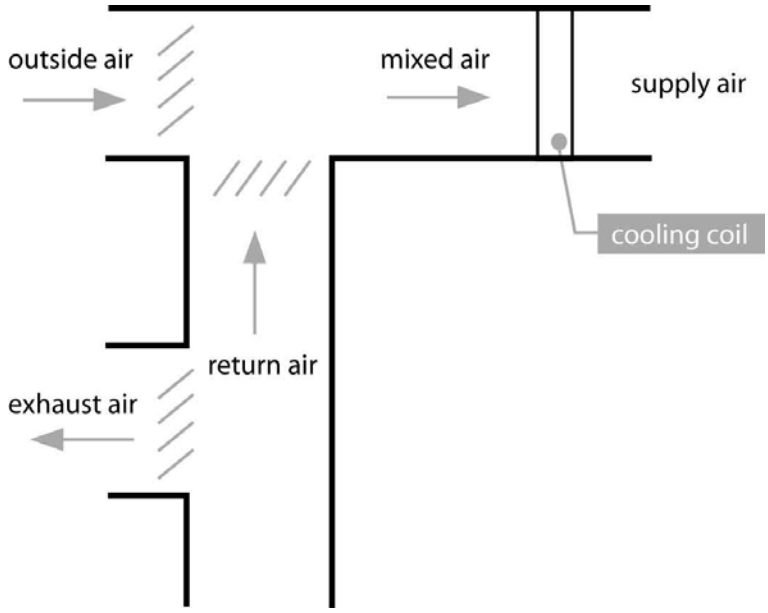
The figure above illustrates an example commercial HVAC system utilizing outside air for ventilation control. An economizer actuator motor usually operates the outdoor air and return air dampers to control the amount of outdoor air brought into the building. (See Application Engineering Bulletin AE-004-05 on Economizers)

However, the system illustrated above does not provide for building pressure control as it provides for bringing outside air into the building but has no exhaust duct and damper.

Supply air is delivered to the building space. An equal amount of air must also be removed from the space. The air removed from the space is called return air. Only a percentage of the return air may be reused. Fresh outside air must be brought into the building to replenish the stale return air before it is again sent to the space as supply air.

When outside air is brought into the space, the same amount of air must be removed from the space through the exhaust air relief dampers otherwise the building pressure would be excessively high. Conversely, if more air is exhausted than brought into the building, the building will experience a negative pressure. A common indication that a building is operating under a negative pressure is when it is difficult to open the outside doors to the building. When opened, a definite suction and rush of outside air enters the building. The exhaust air, outside air and return air dampers operate together. A control system coordinates the operation of the dampers and the power exhaust fan motor according to the building pressure as sensed by a building pressure sensor located inside the building.

After a portion of the return air is exhausted, the remainder is mixed with fresh outside air, filtered and then conditioned by a heating or cooling coil before entering the space.



This diagram illustrates a system that provides for exhaust air as well as outside and return air. The outside and return air dampers are controlled by a single damper actuator motor and a separate actuator motor operates the exhaust air damper.[5]

A building pressure sensor located within the building space, often near the space thermostat, monitors the building pressure with respect to the outside air pressure. The sensor is set to maintain a slightly positive pressure in the building. If the building pressure increases above the sensor's setpoint[6], the exhaust air damper begins opening and allows some of the building's return air to leave the building thus reducing the air pressure in the building. Usually an exhaust fan[7] is also energized to help ensure the exhaust air leaves the building. The exhaust fan may be energized by one of three common methods.

1) The exhaust fan may be turned on when the exhaust damper reaches a pre-determined position.
2) The exhaust fan may be turned on when the outdoor air damper reaches a pre-determined position. The strategy here is that the more the outdoor air damper opens the more outside air enters the building and therefore the greater the building pressure.
3) The exhaust fan motor could operate off a variable frequency drive which will control the amount of air exhausted by varying the CFM of exhaust air thru motor speed control. The variable frequency drive usually receives a signal from the building pressure sensor.

Demand Ventilation

Demand ventilation is a ventilation control strategy which uses a carbon dioxide sensor located in the conditioned space to monitor the amount of carbon dioxide present. As carbon dioxide levels increase above a setpoint value, additional outside air is introduced into the space. An equal portion of space air is exhausted to maintain the desired building pressure. Demand ventilation overrides all other calls for system operation until the space ventilation setpoints have been satisfied. ~~A separate Application Engineering Bulletin covering "demand ventilation" is available.~~

SUMMARY/CONCLUSION:

[5] Other mechanical systems installed in the building can also affect the pressure of the building. Bathroom exhaust fans, independent ventilation fans, chemical ventilation hoods and cooking ventilation hoods are examples. Complete control of the indoor air quality, filtration and building pressure control requires that the entire building operation be considered and integrated into an indoor air quality plan.

[6] "Setpoint" is the setting or adjustment that the sensor is set to maintain. Setpoint is the desired condition.

[7] An exhaust fan or blower is used in addition to the supply air fan or blower. The supply air fan operates continuously during the occupied mode and the exhaust fan operates as necessary to control the building pressure.

- Building construction methods, techniques and materials have improved over the last 25 years so as to make buildings more energy efficient and air tight. Therefore, buildings no longer "breathe" and air becomes trapped in the building.
- Many building materials contain chemicals that "off-gas" to the air. These gasses can be dangerous to human health. Termed, volatile organic compounds or VOCs, many of these compounds have been related to cancer and other severe health concerns.
- The difference in air pressures between the inside and outside of a building have a direct affect on the quality of air in a structure. This building pressure differential can be measured and controlled.
- Commercial HVAC systems can greatly reduce these risks through forced ventilation strategies bringing sufficient amounts of "fresh" outside air into the building while exhausting a portion of "stale" air.
- The supply air, outside air, return air and exhaust air dampers and ducts can be coordinated thru a control system to provide adequate ventilation to the building as a primary method of improving indoor air quality.[8]

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KEY WORDS: (For searches)

- Building pressure control
- Building pressure sensor
- Building static pressure
- Space pressure control
- Static pressure
- Ventilation control
- Outdoor air
- Exhaust air
- Demand ventilation
- Indoor air quality
- IAQ
- Economizers

[8] IAQ, Indoor Air quality is a complex topic. Building pressure control, ventilation and exhaust strategies and filtration techniques are primary methods of improving IAQ. However, for complete control of indoor air quality, an IAQ specialist should be consulted for specific advice pertaining to a given building or application. Information given in this and other Application Engineering Bulletins is intended for use by qualified HVAC professionals only.