UPG
Technical Services

APPLICATION ENGINEERING
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TOPIC: Economizers

SCOPE & PURPOSE:

- This bulletin explains the concept of the economizer, its purpose, construction, function, operation and energy savings potential. The variety of economizer types available is covered. The purpose of this bulletin is to introduce those who need a basic understanding or introduction to economizers to the essentials of economizers.

CONTENT:

Economizer Concept

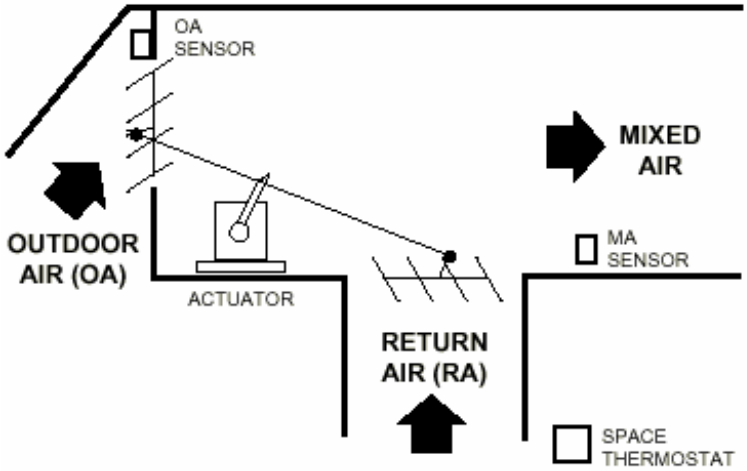
The function of the economizer as its name implies, is to "economize" or save on cooling costs. Obviously, it costs money to operate the compressor. If the compressor can be shut down and the system still provide adequate cooling, energy savings can be realized.[1]

Heat internal to the building such as people, lights, computers, copy machines, motors and other machines causes the temperature inside a structure to increase. Heat soaked up by the building structure may also continue to heat the building long after the

[1] The topic in this bulleting is the "Air Economizer". Other types of economizers are also used in the heating and cooling industry. For example, there are economizer systems used and applied to some boilers. These economizers are not the topic of this bulletin.

temperature outside the building has dropped. There are times when the temperature outside a building is lower than the temperature inside.[2]

Whenever the cooling system space thermostat is calling for cooling and the temperature outside is cool enough it is economical to shut off the compressor and bring in cool outside air to satisfy the cooling needs of the building. Such is the function of an air economizer system. Economizers that monitor the outside air temperature and bring outside air into the building when the outside air is cooler than the indoor air temperature are called "Dry Bulb" controlled economizers.[3]



If the outside air alone is not sufficiently cool to meet the space temperature requirements the thermostat may call for the second stage of cooling. Usually, this brings on the first stage compressor. This is called an "integrated economizer" as it allows the simultaneous use of cool outside air and mechanical cooling if conditions allow.

When the space thermostat calls for cooling the system checks with the OA sensor to see if the outside air is cooler than the indoor air.

If the OA is cooler, the compressor is kept off and the outdoor air damper is opened to utilize the cooler OA to cool the space.

The mixed air (MA) sensor operates the OA and RA dampers to mix the correct amounts of each to provide 55-degree mixed air to the space.

55-degree MA is a generally accepted standard and may be adjusted as necessary.

There is one drawback to this type of control system. Even though the thermostat acknowledges that the outside air temperature is low enough to cool the building, the outside air may be too humid to provide adequate comfort for the building occupants. The occupants will feel cool but clammy. The solution is an economizer that adds a second control which works in harmony with the outdoor thermostat and measures the outdoor air humidity. Such a control is called an "enthalpy" control. The term "enthalpy" means, total heat. The enthalpy control measures both sensible and latent heat

[2] This condition occurs more often than most of us realize. This presents building owners with additional opportunities to reduce cooling energy costs.

[3] Economizers generally mix the proportions of outside and return air to provide a discharge air temperature of 55-degrees F. However, some DDC control systems allow the discharge air temperature to be reset to a slightly higher or lower discharge air setpoint depending upon the need for cooling in the structure. "Reset" is covered in another Application Engineering bulletin.

in the air and only allows outside air to be used for cooling if the air is both cool and dry enough to satisfy the space conditions.

If the indoor thermostat calls for cooling and the outside air enthalpy (total heat) is low enough then the economizer brings in this cooler less humid air and uses it for cooling instead of operating the compressor. Using the outside air for cooling is less expensive than operating the compressor to provide cooling.

So, an enthalpy control is a control which checks to see if both the temperature (sensible heat) and the humidity (latent heat) are low enough to be used for cooling. This combination provides for the greatest comfort at the least cost.

Sensible heat is heat that can be "sensed" or measured as a temperature change on a thermometer. Sensible heat is detected with a standard thermometer called a "dry bulb" thermometer.

A "wet bulb" thermometer is simply a thermometer with a wet cloth over the sensing portion of the thermometer. A wet bulb thermometer measures the moisture content of the air because air totally saturated air (at 100% relative humidity) will not allow any moisture to evaporate from the wet bulb but dry air will allow a great deal of evaporation to take place. The dryer the air, the lower the temperature reading will be on the wet bulb thermometer. Comparing the wet bulb temperature reading to the dry bulb temperature reading allow us to determine the relative humidity of the air.

The "dry bulb" reading provides a measurement of the sensible heat in the air and the wet bulb reading provides a measurement of the latent heat in the air.

Combining the results of the two readings yields the total picture or the "Enthalpy" of the air.

Thus, the enthalpy control operates the economizer according to the total picture of the condition of the outside air.

Enthalpy controls provide the most opportunity for energy savings.

Dual Enthalpy Economizers provide the greatest energy savings potential. Most York International UPG commercial products allow for dual enthalpy control as an option. Upgrading to dual enthalpy is usually an easy field retrofit.

Not all economizers use enthalpy controls. Dry bulb economizers check the outside air temperature and do not check the outside air humidity. Those controls do not provide the same levels of comfort as enthalpy controlled economizers. Most dry bulb controlled economizers can be easily converted/upgraded to operate using an enthalpy control.[4]

Dual Enthalpy Economizers

[4] Most York International UPG produced commercial products utilize an economizer control system which allows the second (Return Air) enthalpy control to begin operating as soon as it is plugged in. "Plug & Play" technology applied to HVAC.

Yet another economizer control system is the "dual enthalpy" controlled economizer. This control system utilizes two enthalpy controls. Dual enthalpy control is also called differential enthalpy control. One enthalpy control senses the enthalpy of the outside air while the other senses the enthalpy of the return air. The two enthalpies are compared to each other by the economizer control system.

When the space thermostat calls for cooling the control system checks both the outdoor air enthalpy control and the return air enthalpy control and utilizes the airstream with the lower enthalpy. Dual enthalpy controlled economizers increase the energy savings potential to a higher degree than the other economizer control systems.

Energy Savings With Economizers

Economizers can save a great deal of energy. Studies show that economizers can typically reduce the energy consumption of a cooling system by 10 to 25%. Generally, the larger the building, the greater the potential for energy savings. The expected energy savings for a building depends upon a number of factors (variables) therefore, the estimated savings and payback must be calculated on a case by case basis. However, economizers are nearly always worth their initial cost and pay for themselves within months.

A study conducted in 1997 by Honeywell determined that the following energy savings were accomplished using each of the following economizer control system sensor types.

	Dry Bulb Only Sensors[5]	OA Enthalpy Sensor	Dual Enthalpy
Los Angles, CA	.25%	31.9%	47.2%
Seattle, WA	.10%	22.1%	28.1%
Madison, WI	.04%	11.4%	25.2%
Albuquerque, NM	.10%	14.6%	20.5%

Dry bulb economizers are the least effective and may never recover the initial cost of installation. Contrary to popular belief, dry bulb economizers are not generally cost effective in dryer areas of the country. Enthalpy type control is highly recommended for all applications and have a much greater cost recovery as well as greater ventilation indoor air quality control than dry bulb controlled economizers.

Economizers can also waste energy if they are not operating properly or are improperly adjusted. For example, if the outside air dampers are not closing properly when the

[5] These values are for comparison only and in no way are a guarantee of what the savings may be on any particular installation. Actual savings may be less or even greater than those listed in this table.

outside air temperature is high, then hot air is unnecessarily entering the building and causing the air conditioning compressor to operate longer and under higher loads thus consuming a great deal more energy than necessary.

If the dampers are open too far during the heating season the heating system must heat the extra outside air entering the structure. Such extra heating and cooling costs can be quite high. The cost of a service call to repair such a problem is often less than the cost of one or two months of energy wasted.

Some economizers are not functioning at all or are out of service because they are not well understood by some service technicians. Many service technicians simply disable them. It is essential that economizers are working properly and saving energy rather than increasing costs.

Since air economizers control and vary the amount of outside (fresh) air brought into a structure, they play an integral role in maintaining the quality of indoor air. A properly operating economizer can greatly improve indoor air quality (IAQ) and reduce air quality related illnesses. Therefore, it is important for the service technician have at least some knowledge of indoor air quality and its relationship to the heating and cooling system operation.

Air economizers are available for residential and commercial systems and can be retrofitted to most systems as energy conserving devices. Most packaged light commercial systems (rooftop systems) have an economizer add-on package as an option which can be installed when the system is new or may added to the system later.

Economizers And Indoor Air Quality

Economizers not only save energy by utilizing “free cooling” when the outdoor air conditions allow the outdoor air to cool the building but, the economizer increases the indoor air quality by introducing more fresh outdoor air to replace the “stale” air in the building. Although it could be argued that outside air is not necessarily “fresh”, outside air is nearly always higher in oxygen content and less contaminated that air that has been trapped in a building for some time.

Indoor air often contains contaminants resulting from the activities taking place in the building. Modern buildings are well insulated, weather-stripped and tighter than older buildings. Construction materials, carpets and furnishings contain adhesives, glues and particulates which off-gas and put fumes in the air. Additionally, when people breathe they absorb oxygen from the air and exhale carbon dioxide. Unless outside ventilation is brought into the space, the indoor air quality quickly degrades. The economizer has a minimum OA setting which continually brings a given percentage of outside air into the building to provide a degree of ventilation to offset the build-up of contaminants in the air. During the ‘free cooling” mode the economizer brings in still more outside air thus increasing the indoor air quality still more.

Installing an economizer or repairing an existing economizer is on of the most effective routes to improving indoor air quality. Adding the demand ventilation feature provides still greater control over indoor air quality.

Demand Ventilation

Some economizers have a demand ventilation feature to further increase the quality of the indoor air. These economizers employ a carbon dioxide sensor place in the space usually near the space thermostat. The sensor monitors the amount of carbon dioxide gas in the space. As people use oxygen and exhale carbon dioxide the oxygen level in the space decreases and the carbon dioxide level increases. The carbon dioxide sensor signals the economizer to open wider allowing more outside air into the space when the carbon dioxide level of the space reaches a preset level. The outside air damper returns to its normal position when the carbon dioxide level returns to an acceptable level in the space.[6]

This type of economizer control is called 'demand ventilation'. Since indoor air quality is a health safety issue, the demand ventilation function overrides all other economizer operations until the carbon dioxide level is at an acceptable level. The desired carbon dioxide levels are adjustable. Many economizer control systems are easily upgradeable to add the demand ventilation feature.

Economizer Maintenance

The following items should be checked at least annually to ensure the air economizer is operating properly:

- Setting & operation of the outdoor thermostat or enthalpy control.
- Condition of the outdoor thermostat or enthalpy control.
- Proper setting and operation of the economizer mixed air thermostat.
- Proper damper operation and lubrication.
- Minimum damper position adjustment.
- Correct operation of the system when a call for cooling comes from the thermostat.

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[6] Carbon dioxide levels are measured in ppm or parts per million. Given a sample of air containing one million parts or air, the number of parts of carbon dioxide can be expressed as a ratio in parts per million. Carbon dioxide sensors are able to sense the value in parts per million for use as in input to the demand ventilation function.

OSHA guidelines limit human exposure in public buildings to a maximum of 5000 ppm of co_2 over an 8-hour period. However, indoor carbon dioxide levels should not be allowed to exceed 1000 ppm at any time. Offices without proper ventilation control often reach the 800 to 1200 ppm level. Tightly packed conference rooms often exceed 2000 to 2500 ppm.

A general guideline is to ventilate indoor spaces to prevent the carbon dioxide level from reaching 1000 ppm while maintaining the indoor level 700 ppm below the level outdoors. Rural outdoor levels average 350 ppm with suburban and city levels at higher but varying levels.

- Function and condition of the economizer damper motor.
- Condition of the wiring and electrical terminations.

Since the enthalpy control is located in the outdoor air air-stream and is a relatively sensitive control, it is not uncommon to have to replace it every few years depending upon the location of the equipment and the weather extremes in the area. The cost of a replacement control is usually recovered quickly through the energy saved. Economizer service should be a part of the scheduled maintenance performed at least on a yearly basis. Outside air introduced into the building mixes with the return air and then passes through the air filters. It is essential to change the filters regularly as another step in the process of protecting the quality of the indoor air.

Economizers utilizing a demand ventilation feature will require additional maintenance and testing to ensure proper operation.

Just as our automobiles need regular service so do residential and commercial heating & cooling systems. Like automobiles, the frequency of service depends upon how it is operated, how often & long it operates and the environment where it operates. Like automobiles, well maintained systems operate more efficiently, last longer and fail less often.

SUMMARY/CONCLUSION:

- Economizers utilize outside air to cool the building whenever conditions allow. Economizers are highly cost effective accessories to a cooling system and usually save enough energy to pay back their initial cost within a short time. There are three general categories of economizer control 1) Dry Bulb 2) Enthalpy and 3) Dual Enthalpy. Studies indicate that dry bulb controlled economizers are the least effective at saving energy and have a poor payback for their initial cost. Additionally, economizers improve indoor air quality by introducing outside air into a building to offset stale indoor air. A Demand Ventilation feature is also available to further increase the level of indoor air quality.
- A separate Application Engineering Bulletin is available covering the setup and adjustment of outside air dampers for their minimum position setting. Most codes require that a certain specified amount of outside air must be introduced into the building anytime the building is occupied. The adjustment of the outside air dampers may require a simple calculation which is covered in the bulletin.

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KEY WORDS (For searches)

- Economizer
- Enthalpy Control
- Demand Ventilation

- Indoor Air Quality
- Free Cooling
- Outdoor Air
- Minimum Position Adjustment
- Differential Enthalpy Control
- Dual Enthalpy Control
- Reset